Assessment of Short- and Mid-term Effects of Wildfire on Habitat Structure in Streams of the Payette National Forest

Prepared For:

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SUMMARY

This report presents the results of our research conducted for the Payette National Forest during 1999. As in previous years, our research was conducted on two groups of streams: (1) tributaries to Big Creek inside the Frank Church Wilderness Area and (2) tributaries to the South Fork of the Salmon River immediately west of the wilderness area. These streams have been variously influenced by wildfires since 1988. The effect of wildfires on stream ecosystems has been the focus of our research over the past several years; however our efforts also are directed towards defining the range of natural variation in wilderness streams (see Royer et al. 1995, Royer and Minshall 1996).

In general, no substantial changes in water chemistry of the streams were observed in the tributaries to Big Creek or the South Fork Salmon River in 1999. Similarly, measurements of physical habitat characteristics have not displayed any consistent pattern over the course of the study. It appears that the 1988 Golden Fire has not, to date, been a major influence on the physical and chemical habitat of Cliff, Cougar, or Goat Creeks. The 1991 Rush Point Fire also appears to have not significantly affected the physical or chemical habitat of Pioneer or Rush Creek. Similarly, in the South Fork Salmon watershed, the 1994 Chicken Fire has not created unstable habitat conditions in Fritser Creek. Overall, the physical and chemical habitat of the study streams has not been altered by the Golden Fire, Rush Point Fire or the Chicken Fire.

Corresponding with the relative stability of the stream's physical and chemical habitat, the biotic components of the study also have not displayed any consistent patterns for evidence of fire effects on these streams. Periphyton has not shown any substantial changes in either chlorophyll-a or biomass/m^2. Because the habitat has not been altered substantially, it is not surprising that the benthic macroinvertebrate community metrics also have remained fairly consistent during the eleven-year study period. Macroinvertebrate density, biomass, species richness and Simpson's Index have not been significantly affected by the Golden, Rush Point or Chicken Fires.

An additional research goal during 1999 was to monitor effects of salvage logging on Big Flat Creek, which is located along the lower portion of the South Fork Salmon River, and to compare it with data collected in 1996 prior to logging and after logging in 1998 and 1999. Although no physical habitat data were collected in 1996, Big Flat Creek was visibly disturbed and macroinvertebrate comparisons show a significant loss in taxa between 1996 and 1998/1999.

The collection of baseline data and the description of natural variation in ecological conditions is a major goal of this research. In this regard, macroinvertebrate density and taxa richness appear to be useful metrics for describing the natural variation in the structure of macroinvertebrate communities in these streams. The several years of data from Cliff, Rush, Pioneer, and Cougar Creeks indicates that relatively stable long-term means exist for both density and taxa richness. The severity of future disturbances may be determined by examining changes in the density and/or number of taxa, relative to the long-term mean in a given stream.

INTRODUCTION

Our field research goal during 1999 was to continue monitoring tributaries to Big Creek and the South Fork of the Salmon River (S.F. Salmon), Idaho that we had examined in previous years. Components of lotic ecosystem structure examined in 1999 included certain chemical and physical characteristics; periphyton abundance; macroinvertebrate distribution, abundance, and diversity; and amount of benthic organic matter. Our primary research goal is to examine the role of wildfire in structuring stream physical and chemical habitat and subsequently influencing benthic algal and invertebrate benthic communities in the Payette National Forest. In addition, our research seeks to define the range of natural variation in both burned and unburned relatively pristine streams (Royer and Minshall 1996, Royer et al. 1995). The studies in the Big Creek catchment were designed to examine the influence of the 1988 Golden Fire and 1991 Rush Point Fire, while those in the S.F. Salmon catchment examined effects of the 1994 Chicken Fire. An additional component was added to the study in 1996: examining the effects of salvage logging on Big Flat Creek along the lower portion of the S.F. Salmon. Smith Creek, adjacent to the timber sale, serves as a reference for Big Flat Creek and was also sampled. Big Flat and Smith Creeks were sampled prior to the onset of the salvage logging, thereby providing a "pre-logging" data set for these sites. This report summarizes eleven years of post-fire data on the Big Creek tributaries, the five-year fire effects on the status of the South Fork Salmon tributaries and the impacts of logging on Big Flat Creek. In addition, the importance of these streams for wilderness monitoring in defining the natural variability found in relatively pristine stream ecosystems is evaluated.

STUDY SITE DESCRIPTIONS

The study streams were located within the Payette National Forest in central Idaho either (1) along Big Creek in the Frank Church 'River of No Return' Wilderness Area or (2) along the South Fork of the Salmon River just outside the wilderness area (Table 1). In both catchments, the streams flow through steep valleys with forested slopes of primarily Douglas-Fir and Ponderosa Pine, also present are extensive bare or sparsely vegetated areas. Open areas of grass and sagebrush are common on the drier slopes in both catchments. The majority of the annual precipitation occurs as snow, resulting in peak flows from late spring through mid-summer. The streams generally remain at baseflow conditions from late summer through autumn.

Catchments of study streams in the Big Creek basin were influenced, to varying degrees, by either the Golden Fire of 1988 or the Rush Point Fire of 1991. The upper portions of the Cliff and Cougar were affected by the Golden Fire; Goat Creek was not burned by the wildfire, but rather by an intentional "back-burn". Cave Creek serves as a reference for these sites. All of the above streams have a southern aspect. The upper portion of the Rush and Pioneer Creek catchments were minimally influenced by the Rush Point Fire and have northern aspects. Thus they provide a comparison with the south-facing streams listed above.

The 72,090 hectare Chicken landscape is located in the lower portion of the South Fork Salmon River Basin, from the confluence of the East Fork SFSR to the confluence of the Main Salmon. The South Fork Salmon River is a major tributary to the Main Salmon within the Columbia River System. The five sites examined included two watersheds: (1) Middle South Fork Salmon River Watershed and (2) Lower South Fork Salmon River Watershed. All of the S.F. Salmon tributaries we examined had a southeastern aspect. In the South Fork Salmon River catchment, Fritser Creek was moderately burned during the Chicken Fire of 1994 but the nearby

Table 1. Location of the 1999 study streams in the Big Creek and South Fork of the Salmon River catchments.

Stream	Elevation	Longitude	Latitude	Township	Range
Big Creek Catchment					
Rush Creek	1170	114° 51' W	45° 07' N	T20N	R13E
Pioneer Creek	1165	114° 51' W	45° 06' N	T20N	R13E
Cave Creek	1220	114° 57' W	45° 08' N	T20N	R13E
Cliff Creek	1195	114° 51' W	45° 07' N	T20N	R13E
Goat Creek	1125	114° 48' W	45° 07' N	T20N	R13E
Cougar Creek	1095	114° 49' W	45° 07' N	T20N	R13E
Big Creek	1150	114° 50' W	45° 06' N	T20N	R13E
South Fork Salmon Catchment					
Circle End Creek	1110	115° 39' W	45° 02' N	T20N	R13E
Tailholt Creek	1110	115° 39' W	45° 02' N	T20N	R13E
Fritser Creek	1036	115° 38' W	45° 05' N	T20N	R13E
Smith Creek	914	115° 31' W	45° 14' N	T20N	R13E
Big Flat Creek	914	115° 33' W	45° 13' N	T20N	R13E

Tailholt and Circle End Creeks were not. Although Tailholt and Circle End were examined beginning in 1994, Fritser Creek was not studied until 1995. Big Flat Creek was extensively burned by the Chicken Fire in 1994 and subsequently logged for salvage in 1996. The reference site, Smith Creek, was considerably larger than any of the logged streams, but provided the only accessible reference stream in immediate area at the time the study was initiated due to numerous road closures related to the logging activities. In 1996 the extremely small size of Big Flat Creek precluded standard channel surveys and only qualitative macroinvertebrate samples were collected. No samples were collected in 1997 because of road closures due to the 1997 spring runoff event.

METHODS

Physical, chemical, and biological parameters were measured in all streams. Measurements of the physical habitat of the channel and water constituents provide important information about current stream conditions and are especially useful in year-to-year comparisons. Biological monitoring gives an indication of past as well as current ecological conditions. The Big Creek tributaries were sampled July 11 to 14 and the South Fork Salmon tributaries were sampled July 5 to 8, 1999. Field methods used for the various portions of this study are summarized in Table 2. The methods were consistent with methods used in our previous studies of wildfire and wilderness streams. These are relatively routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Stednik 1991, Merritt and Cummins 1996, APHA 1992, Platts et al. 1983, Davis et al. *in press*).

Chemical measurements included specific conductance, alkalinity, and hardness. Specific conductance ($\mu S/cm$) was measured in the field with a temperature-compensated Orion meter. Water samples were collected and later analyzed in the laboratory for alkalinity (mg $CaCO_3/l$) and hardness (mg $CaCO_3/l$) by methyl-purple and EDTA standard titration methods, respectively (APHA 1992).

Five transects approximately 50 m apart were sampled to measure substantial changes in channel morphology and riparian conditions over time. Hydraulic gradient was determined with an inclinometer and also a hand level by measuring water surface elevations over several

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method
A. Physical			
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size
Substratum Embed-dedness	R	Visual estimation of 100 randomly selected substrata	Calculate mean substratum embeddedness
Stream Width	T	Measure bankfull width using a nylon meter tape	Calculate mean stream width
Stream Depth	R	Measure water depth at the 100 randomly chosen substrata	Calculate mean water depth
Discharge	T	Velocity/depth profile Velocity measured with an Ott meter	Q=A x v; where Q=discharge, A=cross-sectional area, and V=mean velocity
B. Chemical			
Conductivity	P	Field measurement	Temperature comp-ensated meter (Orion model 126)
Alkalinity	P	Water sample	Methyl-purple titration
Hardness	P	Water sample	EDTA titration
C. Biological			
Invertebrates	R	Collect 5 samples using a Surber sampler	Remove invertebrates, identify, enumerate, and analyze
Benthic Organic Matter	R	Recover from Surber samples	Determine AFDM
Periphyton	R	Collect 5 samples from individual substrata	Methanol extraction and spectrophotometric analysis

* P=point measure; T=transect across stream; R=random throughout a defined reach.

substantial reach lengths to give a good estimate of the mean. Gradient equals rise in stream height divided by the length of the stream reach examined. Stream discharge (m^3/s) was calculated at one cross-sectional transect by separating the transect into increments and multiplying the velocity by the cross-sectional area of the flow of each increment and then summing the increments (Bovee and Milhous 1978). An Ott C-1 current meter was used to determine mean water velocity (m/s) at 0.6 water depth. Mean substratum size, % embeddedness, and water depth were measured at 100 locations throughout the channel and along approximately 200 m of stream reach (Platts 1983).

Benthic algal samples were collected from five riffle/run rocks, one near each transect, using an areal sampler. A plastic tube was placed over the area of the substratum to be sampled. A neoprene gasket sealed the tube to the substrate and prevents the leakage of dislodged material. A known area (3.14 cm^2) was brushed using a hard bristled toothbrush and a syringe was used to remove the slurry and deposit it on a 0.45 um pre-ashed glass fiber filter. Samples were immediately filtered and frozen with liquid nitrogen (and kept in the dark) to prevent degradation. In the laboratory, algal abundance was calculated by quantifying ash-free dry mass and chlorophyll *a* using standard methods (APHA 1992).

Methods used for sampling benthic macroinvertebrates are described in Platts et al. (1983) and Merritt and Cummins (1996) Briefly, five quantitative Surber samples (929 cm^2 with a 250μm mesh capture net) were collected from riffle/run habitats and preserved in 10% formalin. In the laboratory each macroinvertebrate sample was hand-sorted and identified to the lowest feasible taxonomic level using standard identification keys (Merritt and Cummins 1996, and others). After identification, the macroinvertebrates were dried at 50^0 C, and weighed with an electrobalance to determine biomass. Benthic macroinvertebrate communities were examined in terms of density, biomass, taxa richness, and Simpson's Index. In addition, %Ephemeroptera (E), Plecoptera (P), and Trichoptera (T) and %Diptera were calculated for each stream. %EPT is frequently reported because of the sensitivity to pollution exhibited by members of these groups as a whole. The sorting process separated the macroinvertebrates from the organic matter that occured in the sample. The leftover organic matter then was dried and ashed to determine standing stock of benthic organic matter (BOM) in the stream.

RESULTS

Big Creek Tributaries

In general, no substantial changes in water chemistry of the streams have been observed in the Big Creek tributaries over the eleven year study period (Table 3). In 1999, alkalinity, hardness, and specific conductance were lowest at Cave Creek and highest at Goat Creek. Alkalinity ranged from 29 to 62 mg $CaCO_3$/l; hardness ranged from 61 to 105 mg $CaCO_3$/l, and specific conductance, from 66 to 161 μS/cm@25^{0}C. These values were all within the long-term averages and no substantial temporal change was observed regardless of percent catchment burned or degree of physical disturbance.

Discharge (m^3/s) for all streams in 1999 except Rush Creek fell within the eleven year average. Rush Creek discharge (2.21) was slightly higher than the long-term average (1.58 m^3/s). The measurements of most physical habitat features in the streams also have not varied substantially and/or in any consistent manner over the course of the study (Table 4). However, Cougar Creek has increased in bankfull width over the past three years, to the widest of the study period, 4.2 m from a long term average of 2.7 ± 0.6 m. In 1999, substrate embeddedness decreased in Rush, Pioneer, Cave and Cliff Creeks, but increased substantially in Goat and Cougar Creeks, from approximately 5% to 25% embeddedness. Mean substrate size in Goat Creek decreased from 16 to 9 cm between 1998 and 1999.

Mean values of periphyton chlorophyll-a remained the same or decreased in all streams between 1998 and 1999 except in Rush Creek (Figure 1). Periphyton chlorophyll-a values were fairly low compared to the 10-year average for all streams (Figure 1). Periphyton ash-free dry mass (AFDM) values decreased at all sites from 1998 to 1999. Rush had the highest mean AFDM in 1999. Goat and Cougar also had relatively high AFDM means (Figure 2). Mean benthic organic matter (BOM) associated with the Surber samples was highest in Goat Creek in 1999, but extremely variable, as it has been in past years (Figure 3). Values remained fairly consistent between 1998 and 1999 for all streams and were within the eleven-year range (Figure 3). All values for periphyton AFDM were also within the long-term range.

Benthic macroinvertebrate mean density ranged from 4945 in Cougar to 13,900 individuals/m^2 in Pioneer Creek (Figure 4). Reference stream Cave Creek density was 8073

Table 3. Discharge and chemical measures for the study streams in the Big Creek catchment.

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)	pH
Rush	1988	1.61	36	30	110	7.8
	1991				103	8.2
	1992	1.10	46	46	95	8.4
	1993	0.31				7.9
	1994	1.56			77	
	1995	1.75	32	57	76	8.2
	1996	1.59	36	80	99	8.5
	1997	1.94	30	65	85	7.4
	1998	2.17	32	48		
	1999	2.21	33	78	90	
Pioneer	1990	0.16	62	86	88	8.1
	1991	0.01			125	8.0
	1993	0.02	26	48	72	
	1994	0.17			113	
	1995	0.21	42	81	135	7.9
	1996	0.11	40	70	119	7.7
	1997	0.16	36	77	108	8.1
	1998	0.23	41	52		
	1999	0.20	46	93	127	8
Cave	1990	0.31	24	44	39	7.9
	1993	0.08	19	24	55	
	1994	0.21				
	1995	0.17	20	40	48	8.1
	1996	0.22	44	48	66	7.8
	1997	0.29	20	36	64	7.9
	1998	0.34	39	73		
	1999	0.37	29	61	66	7.9
Cliff	1988	0.04			67	8.4
	1990	0.32	35	66	61	8.2
	1991	0.18	77	71	73	8.2
	1992	0.08	48	49	99	8.0
	1993	0.09	26	44	77	7.7
	1994	0.10			79	
	1995	0.15	34	53	93	8.2
	1996	0.14	32	42	105	7.3
	1997	0.17	24	57	86	8.0
	1998	0.19	32	103		
	1999	0.18	36	82	97	7.7
Goat	1990	0.01	86	110	139	8.1
	1991	0.09	49	51	153	8.4
	1992	0.01	80	76	151	8.2
	1993	0.01	41	68	116	8.1
	1994	0.01			148	
	1995	0.01	56	93	140	8.1
	1996	0.04	50	68	157	8
	1997	0.03	48	89	174	
	1998	0.05	43	156		
	1999		62	105	161	8.2
Cougar	1990	0.11	46	71	70	8.5
	1991	0.10	36	32	93	7.4
	1992	0.01	59	60	113	8.2
	1993	0.02	33	48	94	7.7
	1994	0.08				
	1995	0.10	48	85	107	8.2
	1996	0.15	52	80	158	8.2
	1997	0.13	44	89	174	
	1998	0.15	38	107		
	1999	0.13			143	8.3

Table 4. Substrate particle size and channel morphology measures for study streams in the Big Creek catchment. SD = standard deviation, CV = coefficient of variation.

Stream	Year	Substrate Size (cm) mean (n=100)	SD	CV	Substrate Embeddedness (%) mean (n=100)	SD	CV	Bankfull Width (m) mean (n=5)	SD	Baseflow Depth (cm) mean (n=100)	SD
Rush	1988	14.6	14.0	0.96				15.1		35.0	10.0
	1992	13.3	9.2	0.69	18.8	26.7	0.96	12.0		21.0	10.0
	1993	21.3	14.8	0.69	35.0	28.9	0.51	13.4	1.5	26.2	7.3
	1994	13.9	13.2	0.95	39.3	34.0	0.46	6.3	4.8	26.2	7.9
	1995	22.6	16.7	0.74	25.0	26.2	1.05	11.8	0.6	35.0	10.3
	1996	21.0	20.0	0.95	30.0	36.0	1.20	13.9	2.4	25.4	15.0
	1997	18.0	17.0	0.94	38.0	28.0	0.74	12.1	1.2	27.0	14.0
	1998	14.1	11.1	0.78	22.5	28.2	1.25	13.8	1.8	33.2	12.5
	1999	15.5	12.2	0.79	18.3	27.4	1.50	11.2	0.6	31.5	13.6
Pioneer	1990	16.7	14.0	0.84	12.5	23.9	1.44	3.4		16.0	4.5
	1993	19.5	18.7	0.96	33.8	28.8	0.53	2.9	0.9	15.3	7.7
	1994	13.9	15.2	1.09	34.3	33.7	0.53	1.7	4.2	18.0	7.9
	1995	15.2	17.4	1.14	45.3	36.3	0.80	3.0	0.6	17.5	10.1
	1996	17.0	20.0	1.18	44.0	40.0	0.91	2.7	0.5	14.7	9.3
	1997	18.0	17.0	0.94	20.0	28.0	1.40	2.6	0.6	17.0	9.0
	1998	16.0	17.1	1.07	18.3	25.2	1.38	2.9	0.4	17.8	8.9
	1999	13.9	16.0	1.15	17.3	21.7	1.26	2.4	0.3	18.2	14.6
Cave	1990	18.8	12.2	0.65				6.1		15.0	6.0
	1993	18.2	17.0	0.93	59.8	29.8	0.30	5.4	0.5	15.3	8.1
	1994	18.3	15.9	0.87	45.0	33.9	0.40	4.1	8.1	15.6	9.5
	1995	15.1	18.7	1.24	56.5	33.1	0.59	5.2	1.2	18.8	7.9
	1996	16.0	11.0	0.69	14.0	21.0	1.50	5.0	0.8	15.7	9.7
	1997	15.0	11.0	0.73	23.0	26.0	1.13	5.1	1.0	20.0	11.0
	1998	18.6	29.4	1.58	31.3	32.2	1.03	5.3	1.1	21.6	10.5
	1999	16.3	18.1	1.11	28.3	28.4	1.00	5.0	0.3	20.1	8.7
Cliff	1988	16.2	10.2	0.63				4.8		13.6	7.2
	1990	25.3	17.7	0.70				3.5		20.0	4.0
	1991	22.5	20.3	0.90				3.8		20.0	8.0
	1992	26.8	26.8	1.00				5.5		20.0	14.0
	1993	21.5	16.8	0.78	41.8	31.6	0.43	3.2	0.7	16.4	8.3
	1994	19.5	16.3	0.84	40.9	30.8	0.44	2.0	6.4	20.9	10.2
	1995	21.5	24.4	1.13	66.0	73.4	1.11	3.5	0.7	22.1	10.7
	1996	21.0	27.0	1.29	41.0	39.0	0.95	4.2	1.5	11.1	8.1
	1997	20.0	15.0	0.75	19.0	23.0	1.21	3.0	0.3	18.0	10.0
	1998	21.7	21.4	0.98	25.3	26.3	1.04	3.0	1.0	22.9	11.7
	1999	22.0	25.0	1.14	21.3	25.1	1.18	4.3	1.4	17.3	10.1
Goat	1990	9.7	16.5	1.70				0.9		10.0	2.0
	1991	10.9	16.4	1.50				0.9		10.0	3.0
	1992	13.1	17.0	1.30				0.8		10.0	7.0
	1993	17.5	16.6	0.95	43.8	35.4	0.41	1.1	0.3	12.0	4.1
	1994	11.7	16.1	1.38	68.5	31.1	0.26	0.9	0.2	10.4	4.4
	1995	12.0	14.0	1.16	65.3	34.5	0.53	1.2	0.3	10.8	5.7
	1996	24.0	27.0	1.13	55.0	37.0	0.67	1.3	0.2	5.9	4.1
	1997	7.0	10.0	1.43	11.0	20.0	1.82	0.8	0.7	12.0	5.0
	1998	16.2	24.2	1.49	2.8	9.3	3.38	2.3	0.8	8.8	7.9
	1999	9.2	9.9	1.07	22.8	25.5	1.21	1.6	0.4	10.4	6.4
Cougar	1990	21.6	13.0	0.60				2.7		20.0	
	1991	22.6	27.1	1.20				3.1		20.0	6.0
	1992	13.0	14.3	1.10				2.6		20.0	20.0
	1993	21.1	20.9	0.99	42.5	30.5	0.42	2.5	0.9	16.3	8.1
	1994	15.5	11.9	0.77	50.3	33.8	0.36	1.6	0.7	18.8	10.3
	1995	19.2	17.1	0.89	47.5	31.5	0.66	2.5	0.6	20.3	11.3
	1996	20.0	24.0	1.20	46.0	39.0	0.85	2.8	0.5	12.7	8.0
	1997	18.0	14	0.78	18.0	23.0	1.28	2.7	0.7	18.0	10
	1998	19.5	21.5	1.10	7.0	15.0	2.15	3.8	0.6	18.4	12.6
	1999	20.4	20.4	1.00	29.8	26.6	0.89	4.2	1.3	20.2	11.5

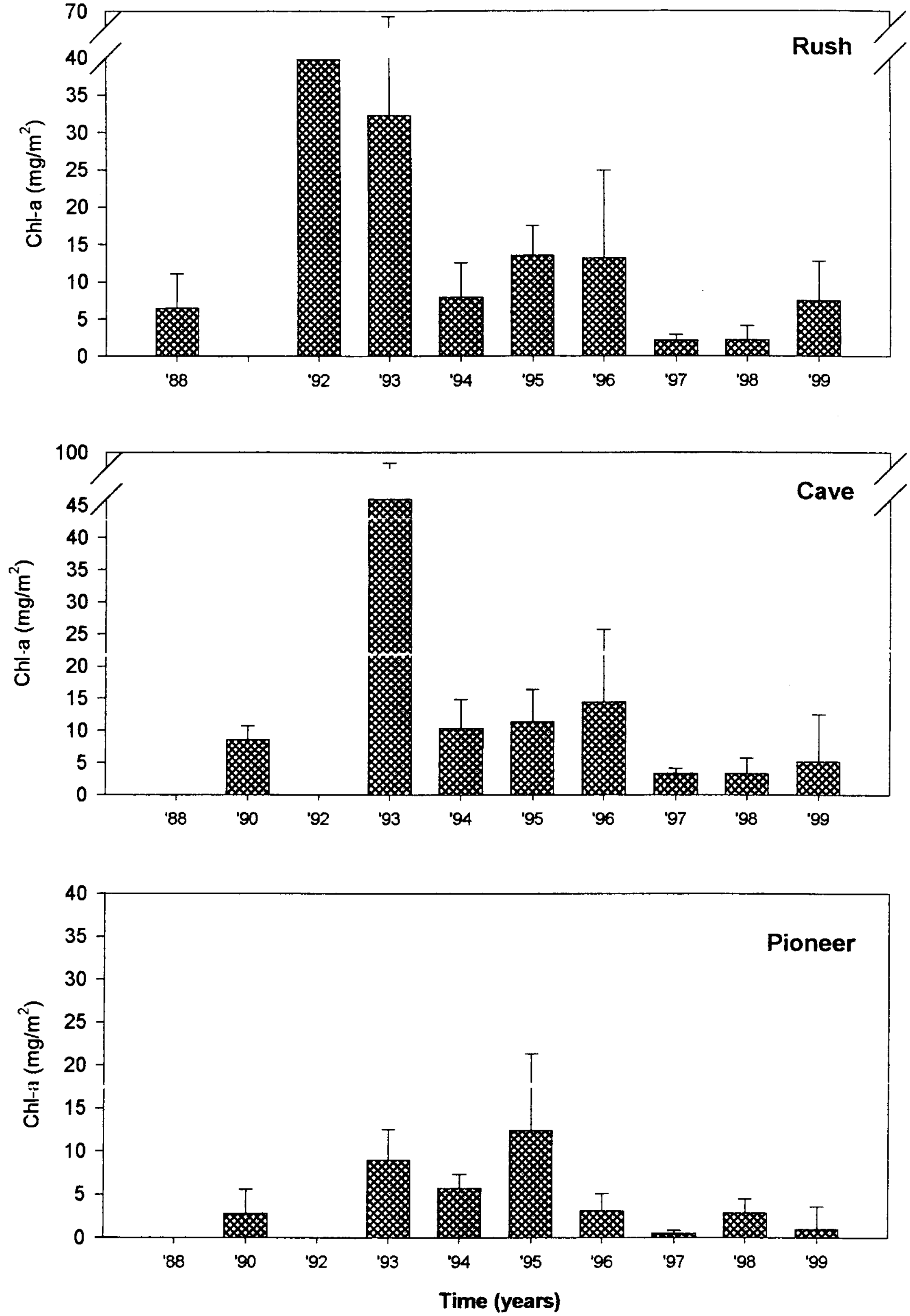
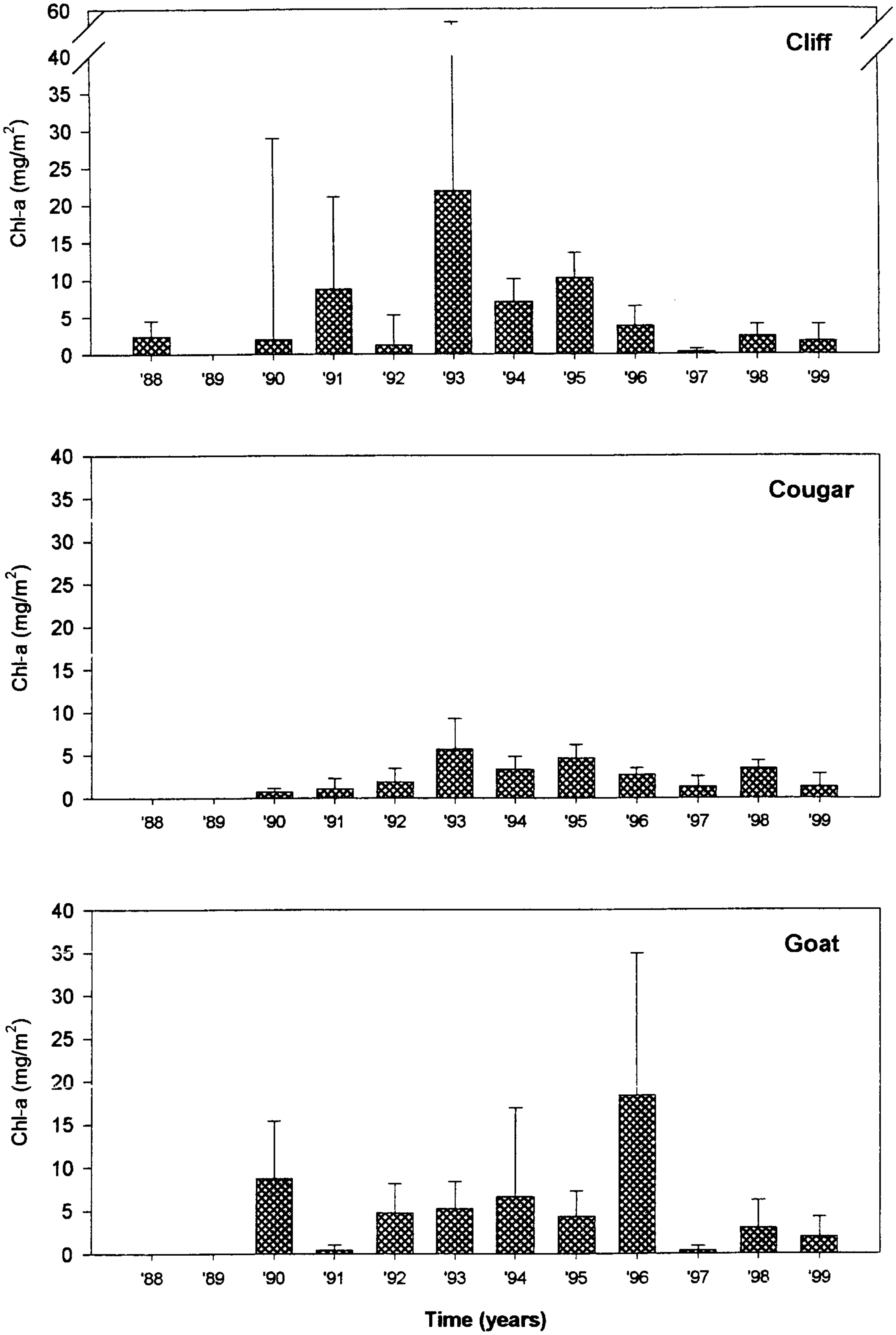


Figure 1. Mean values of periphyton chlorophyll *a* for the study streams. Error bars equal +1SD from the mean, n=5.



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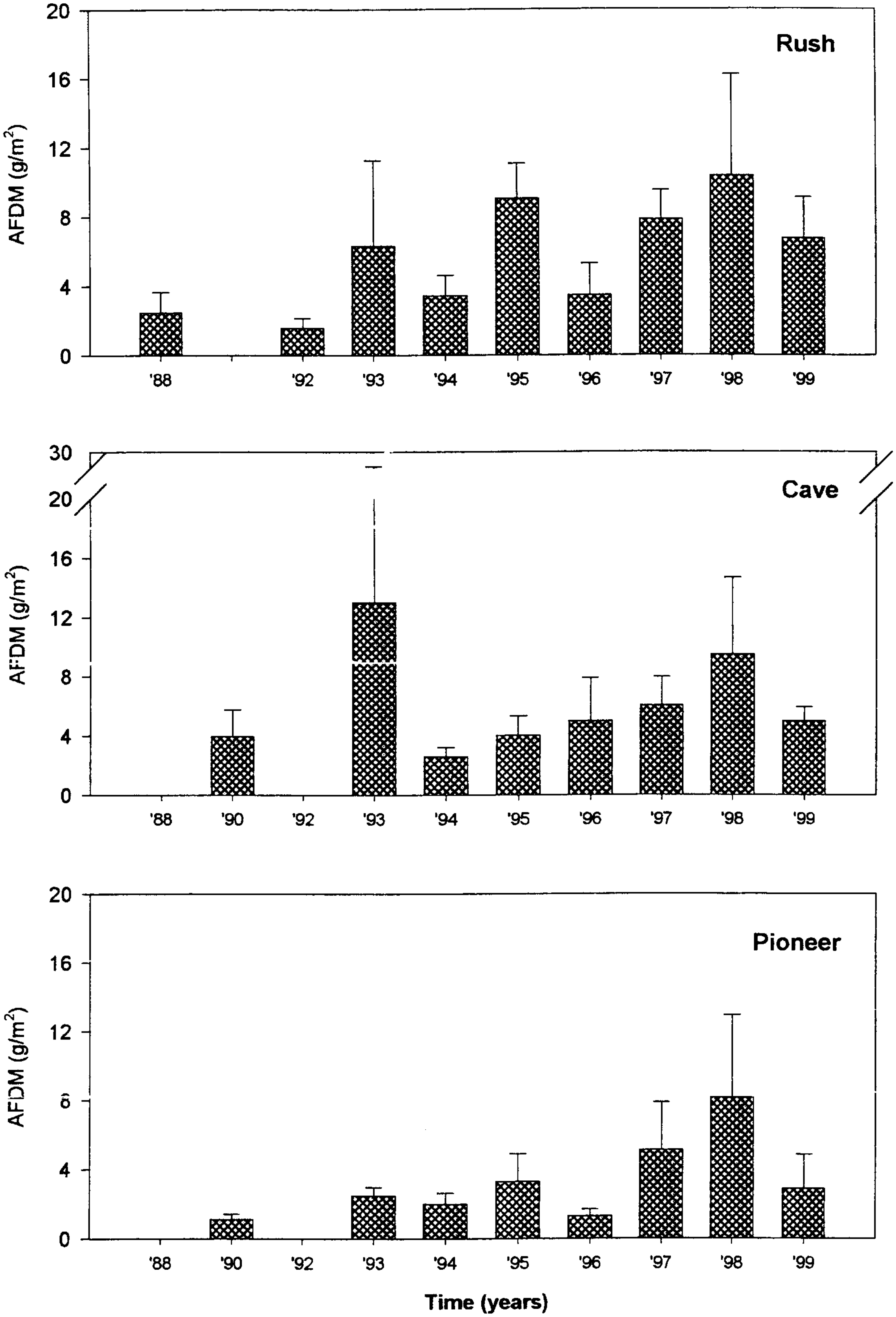
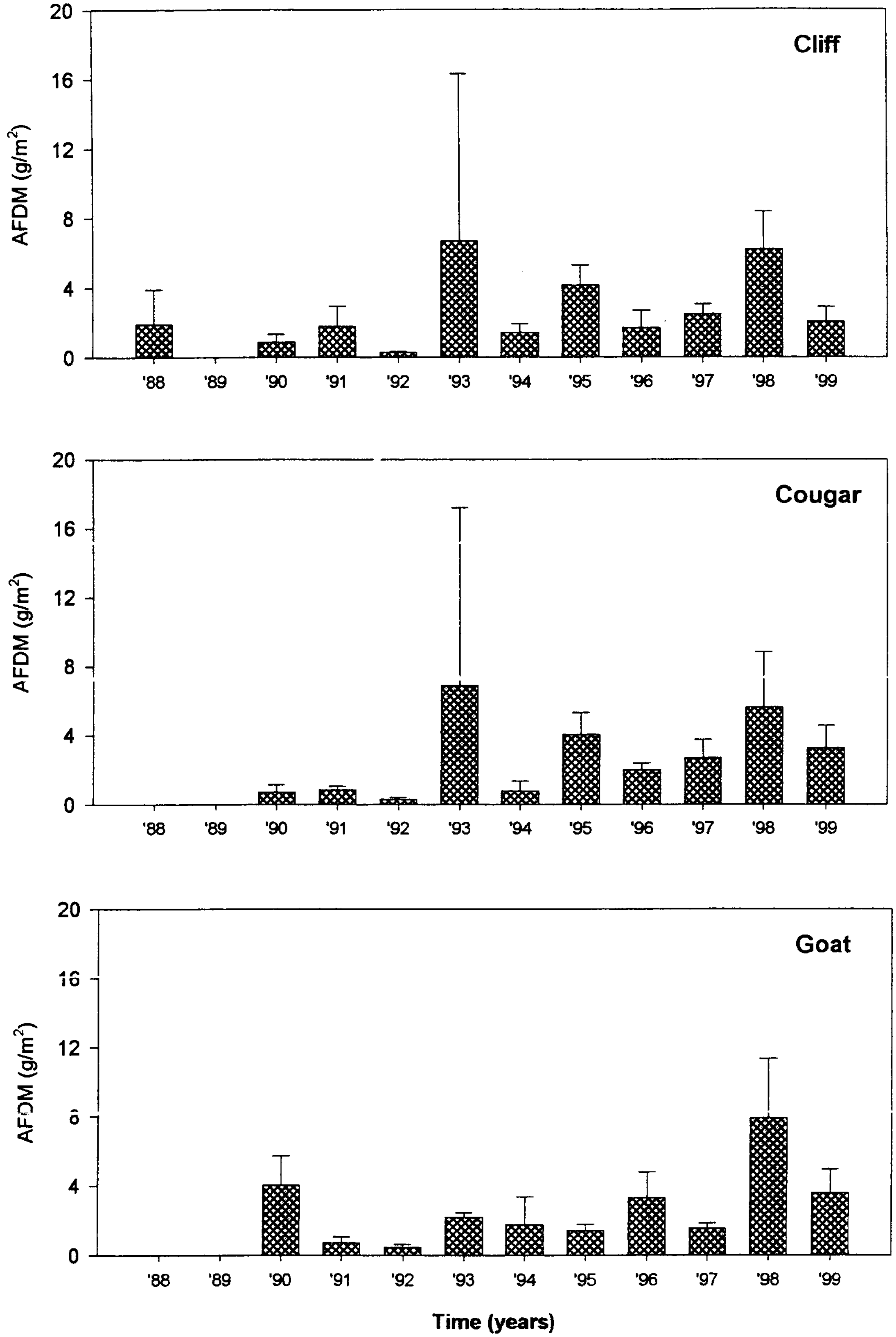


Figure 2. Mean values of periphyton ash-free dry mass (AFDM) for the study streams. Error bars equal +1SD from the mean, n=5.



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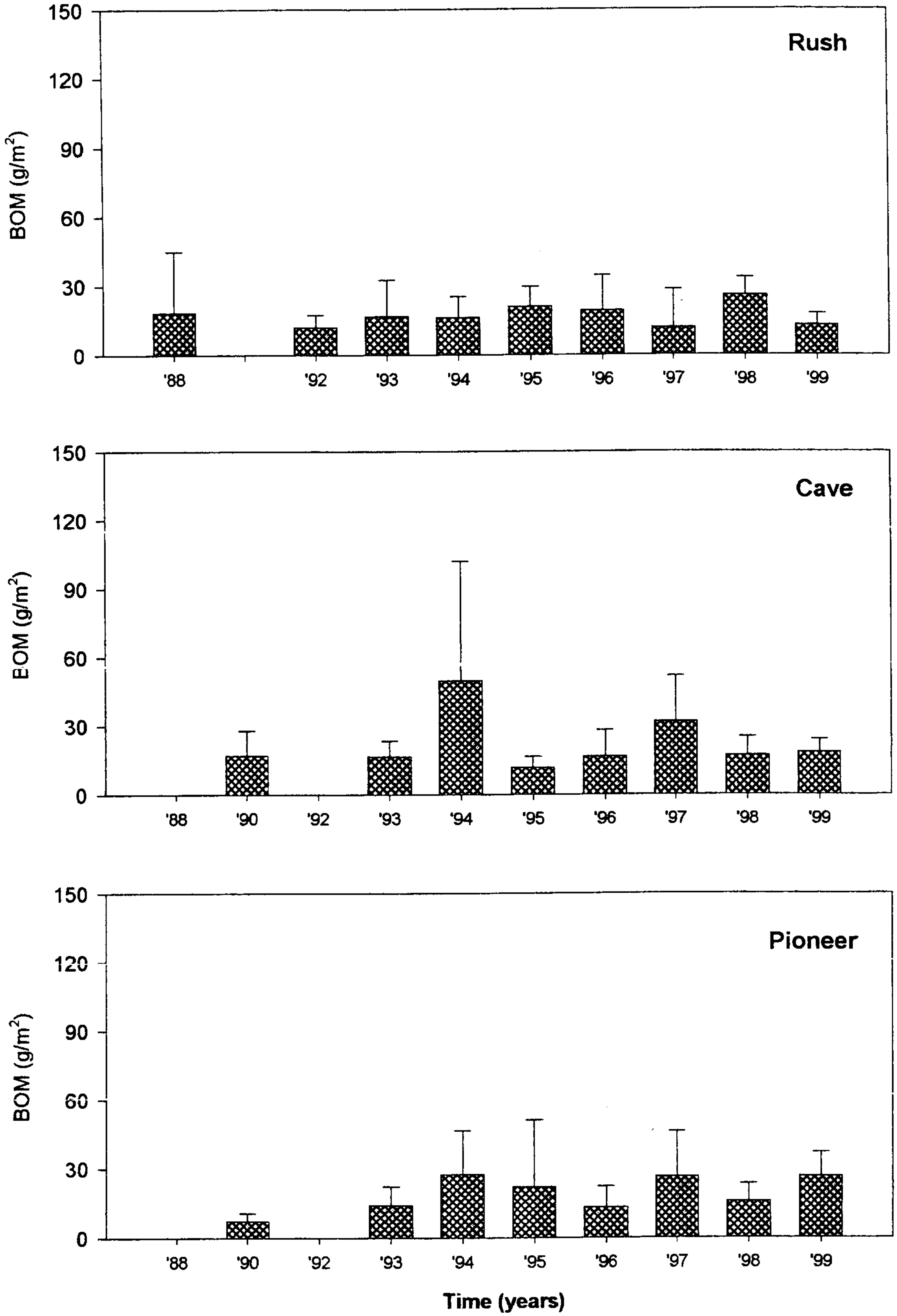

Figure 3. Mean dry mass of benthic organic matter (BOM). Error bars equal +1SD from the mean, n=5.

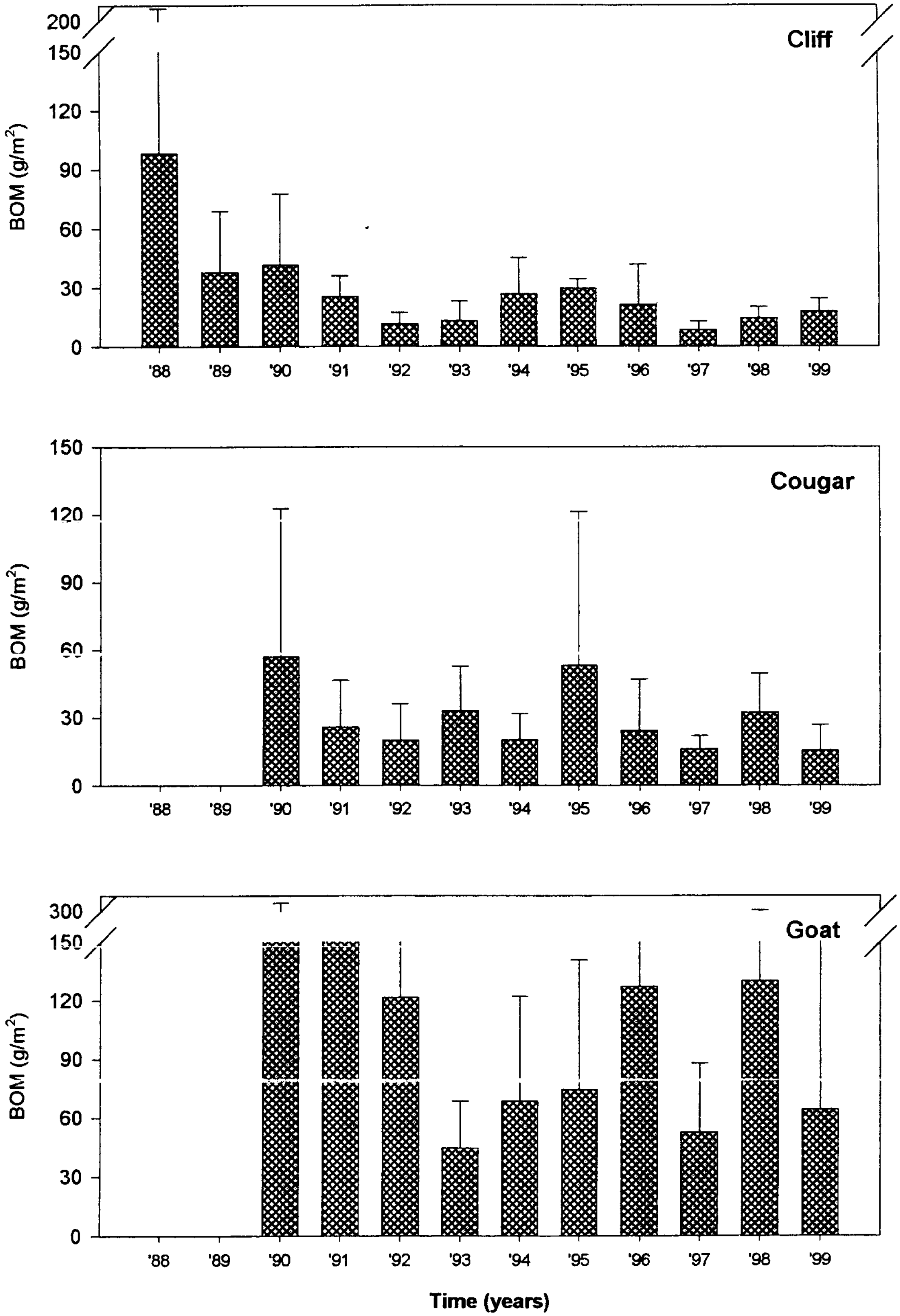

Figure 3. continued.

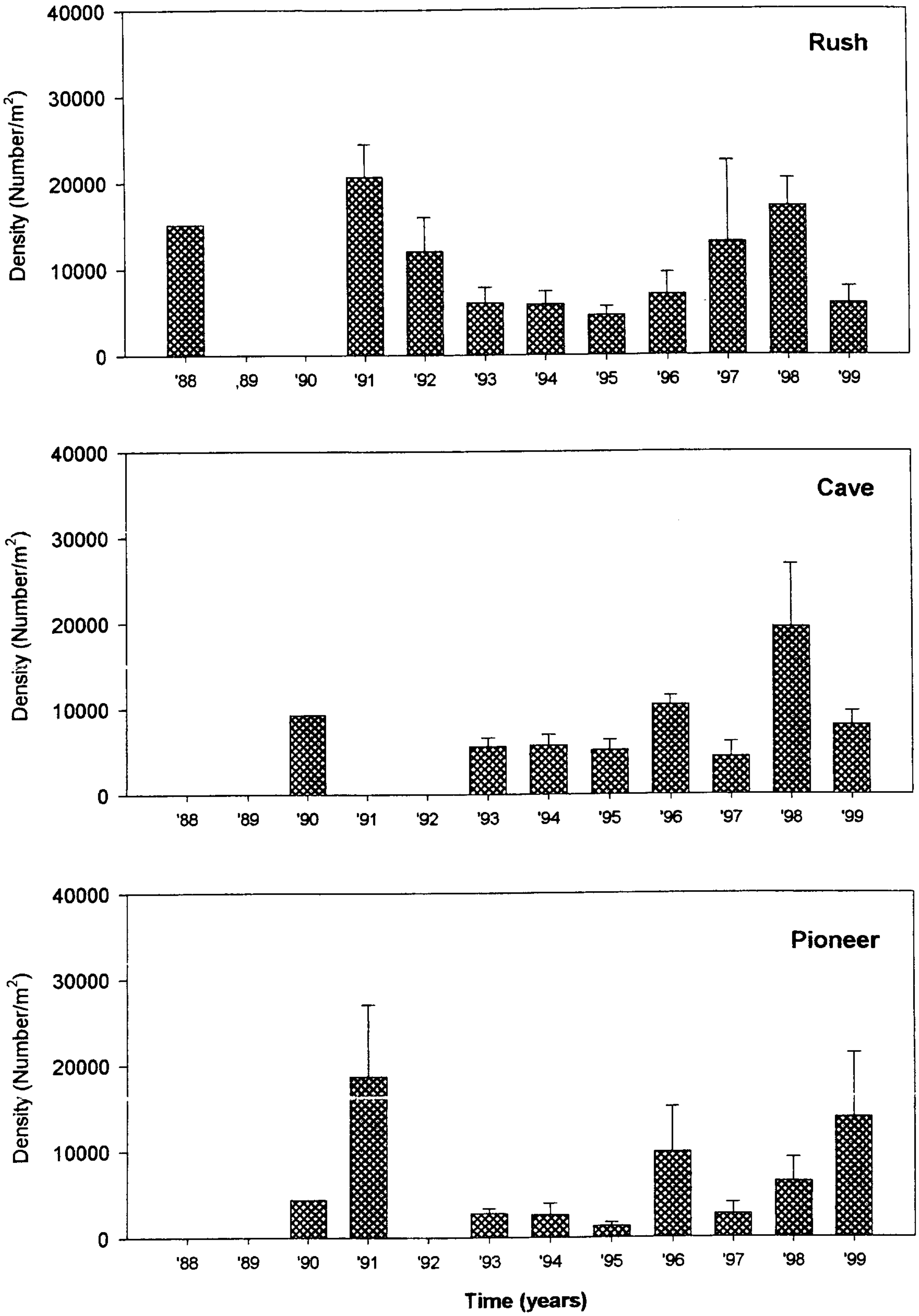

Figure 4. Mean macroinvertebrate density for each stream. Error bars equal +1SD from the mean, n=5.

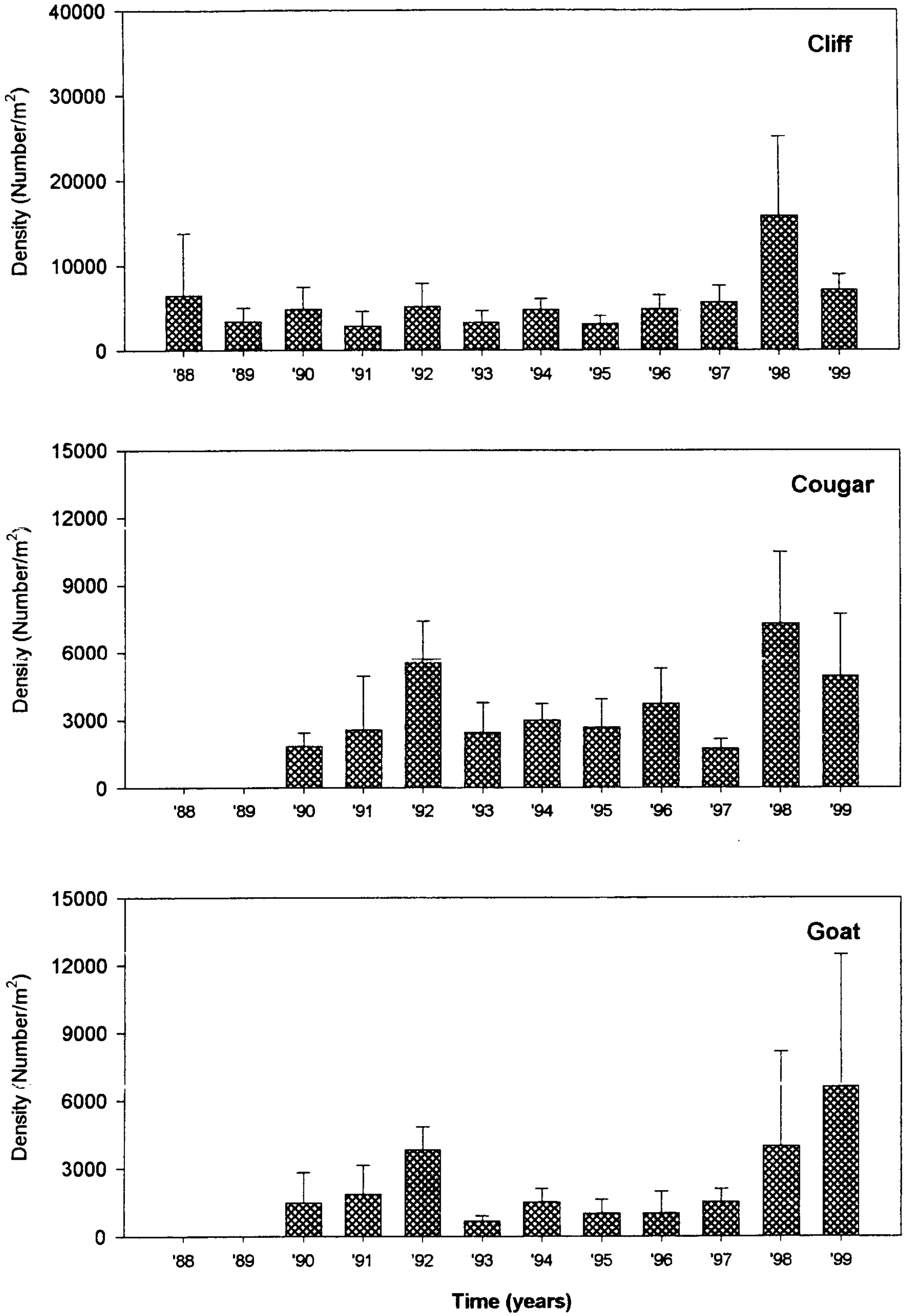

Figure 4 continued.

individuals/m^2. Densities in 1999 were lower than in 1998 for all streams except for Goat and Pioneer (Figure 4). Goat Creek mean density, 6613 individuals/m^2, was the highest density recorded in that stream in the nine years that it has been sampled, but had a high standard deviation (5851 individuals/m^2). The previous eight years averaged 1500 individuals/m^2. Other than Goat Creek, densities in all streams fall within their respective long-term ranges. Cliff Creek, which experienced a density peak in 1998 of approximately 16,000 individuals/m^2, has returned to the long-term average of 3,500-7,000 individuals/m^2 experienced prior to 1998. In Pioneer Creek, Oligochaeta was the most common taxon and comprised 53% of the relative abundance (Table 5). Oligochaeta was the most common taxon in all streams except for Cave Creek, but the relative abundance was lower in the streams other than Pioneer, ranging from 28-37%. Chironomidae was the most common taxon in Cave Creek, comprising 16% of the community, with Oligochaeta closely second with 13% of the relative abundance.

Macroinvertebrate mean biomass was lowest in Rush Creek, 499 mg/m^2 and highest in Goat Creek, 1784 mg/m^2 (Figure 5). Mean biomass for Goat Creek during the previous five years (1994-1998) was less than 300 mg/m^2. Corresponding with densities, this is the highest biomass recorded in Goat Creek but the standard deviation (2631 mg/m^2) was higher than the mean. Rush Creek, on the other hand, had the lowest benthic macroinvertebrate mean biomass recorded in the eleven-year period in that stream. Except for Goat and Pioneer Creeks, biomass numbers were similar to 1998 values and fell within the long- term range (Figure 5). Biomass was more stable over time in all streams relative to density. Although mean density decreased in Cave Creek by nearly 10,000 individuals/m^2, biomass was relatively consistent between 1998 and 1999. In Cliff Creek, although density decreased by approximately 10.000 individuals/m^2 between years, biomass increased slightly.

Taxa richness ranged from 29 to 43 taxa at Rush and Cave Creeks, respectively (Figure 6). Mean taxa richness decreased in all streams between 1998 and 1999, especially at Rush and Cougar Creeks. Variance between samples at these streams was low, 4 and 3 taxa, respectively. Both streams decreased by approximately 20 taxa. However, values for all streams corresponded with the long-term trend, they are just lower than the previous two years where a richness spike seemed to occur in most streams (Figure 6). Simpson's Index, which takes into account the relative abundance of individual taxa, was lowest at Cave Creek, 0.10, and highest at Pioneer,

Table 5. Relative abundances of the 15 most common macroinvertebrate taxa from each stream, 1999. SD = one standard deviation from the mean, n=5.

Rush

	Mean	SD
Oligochaeta	0.348	0.094
Chironomidae	0.141	0.080
Hydracarina	0.117	0.037
Serratella tibialis	0.048	0.039
Baetis	0.046	0.021
Cinygmula	0.045	0.018
Epeorus	0.044	0.018
Sweltsa	0.030	0.007
Heptageniidae	0.030	0.018
Simulium	0.029	0.026
Drunella doddsi	0.023	0.016
Rhithrogena hageni	0.016	0.010
Deuterophlebia	0.014	0.009
Epeorus longimanus	0.013	0.004
Optioservus	0.007	0.004

Cave

	Mean	SD
Chironomidae	0.159	0.061
Oligochaeta	0.133	0.088
Hydracarina	0.119	0.043
Baetis	0.103	0.029
Heterlimnius	0.073	0.028
Ephemerellidae	0.048	0.011
Epeorus longimanus	0.044	0.032
Drunella doddsi	0.044	0.017
Serratella tibialis	0.042	0.021
Epeorus	0.035	0.020
Brachycentrus americanus	0.022	0.015
Ostracoda	0.020	0.007
Leuctridae	0.017	0.014
Simulium	0.016	0.014
Perlidae	0.014	0.006

Pioneer

	Mean	SD
Oligochaeta	0.530	0.134
Ostracoda	0.082	0.025
Baetis	0.071	0.035
Heterlimnius	0.056	0.012
Cinygmula	0.050	0.011
Epeorus	0.035	0.014
Chloroperlidae	0.021	0.009
Chironomidae	0.015	0.006
Epeorus longimanus	0.014	0.010
Hydracarina	0.013	0.006
Zapada	0.011	0.010
Epeorus grandis	0.009	0.006
Perlidae	0.009	0.002
Rhyacophila	0.008	0.002
Copepoda	0.007	0.004

Cliff

	Mean	SD
Oligochaeta	0.281	0.193
Epeorus	0.126	0.080
Drunella doddsi	0.088	0.069
Zapada	0.083	0.047
Baetis	0.049	0.015
Rhithrogena	0.047	0.025
Cinygmula	0.042	0.022
Ostracoda	0.039	0.009
Epeorus grandis	0.035	0.028
Chironomidae	0.031	0.015
Simulium	0.027	0.033
Hydracarina	0.015	0.006
Sweltsa	0.014	0.009
Heterlimnius	0.014	0.010
Prosimulium	0.013	0.023

Cougar

	Mean	SD
Oligochaeta	0.373	0.212
Baetis	0.124	0.032
Heterlimnius	0.103	0.069
Ostracoda	0.049	0.036
Cinygmula	0.044	0.023
Chironomidae	0.037	0.018
Epeorus	0.036	0.031
Zapada	0.035	0.016
Hydracarina	0.028	0.030
Sweltsa	0.020	0.022
Drunella doddsi	0.018	0.019
Epeorus longimanus	0.014	0.009
Epeorus grandis	0.012	0.010
Rhyacophila brunnea	0.008	0.004
Rhithrogena	0.008	0.005

Goat

	Mean	SD
Oligochaeta	0.284	0.174
Chironomidae	0.158	0.067
Baetis	0.118	0.119
Elmidae	0.083	0.077
Nematoda	0.050	0.048
Heterlimnius	0.050	0.028
Ostracoda	0.044	0.032
Hydracarina	0.042	0.024
Zapada	0.026	0.023
Drunella coloradensis	0.019	0.020
Copepoda	0.011	0.016
Ephemerellidae	0.009	0.005
Nemouridae	0.009	0.013
Collembola	0.008	0.009
Amphinemura	0.008	0.013

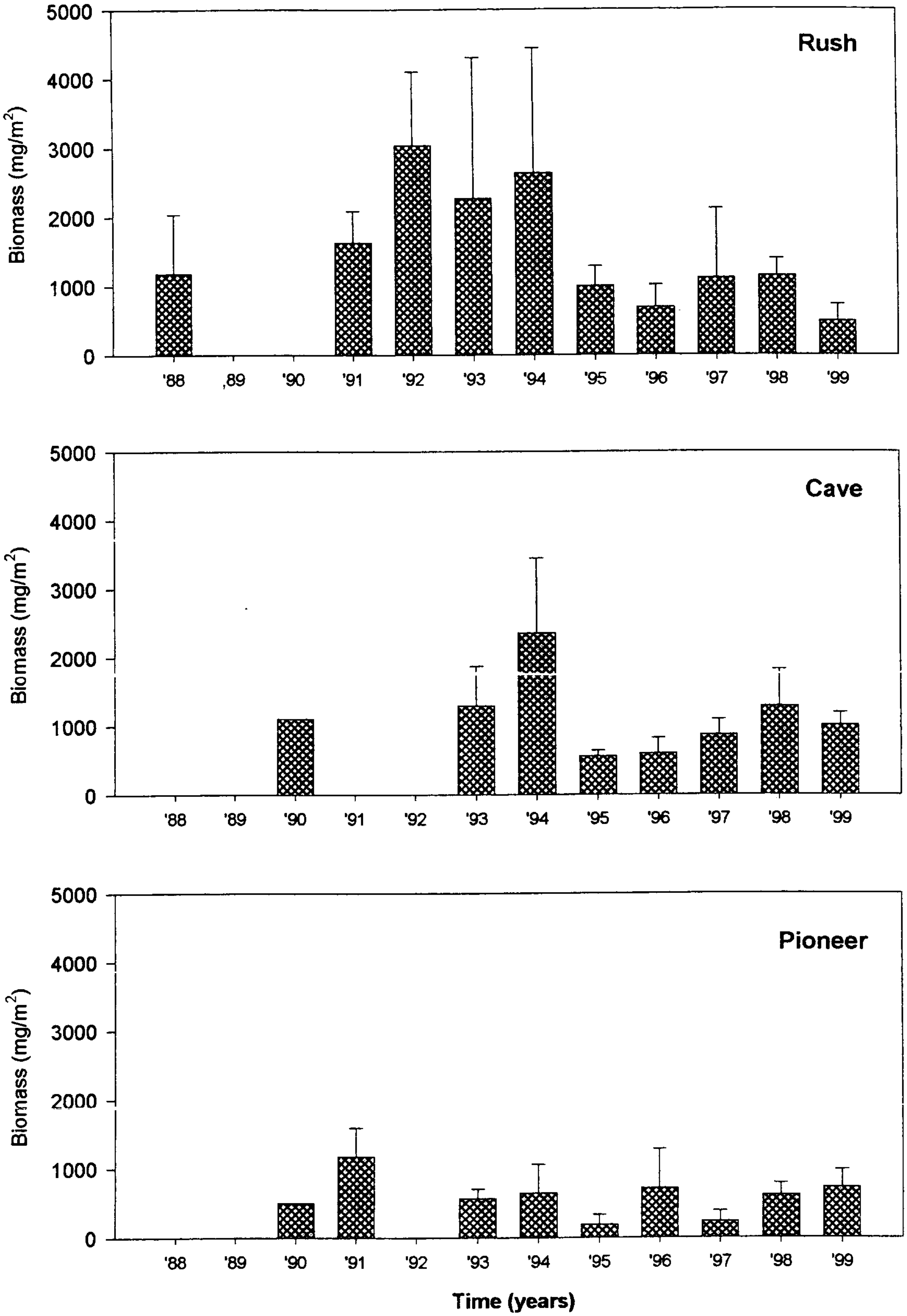

Figure 5. Mean macroinvertebrate biomass for each stream. Error bars equal +1SD from the mean, n=5.

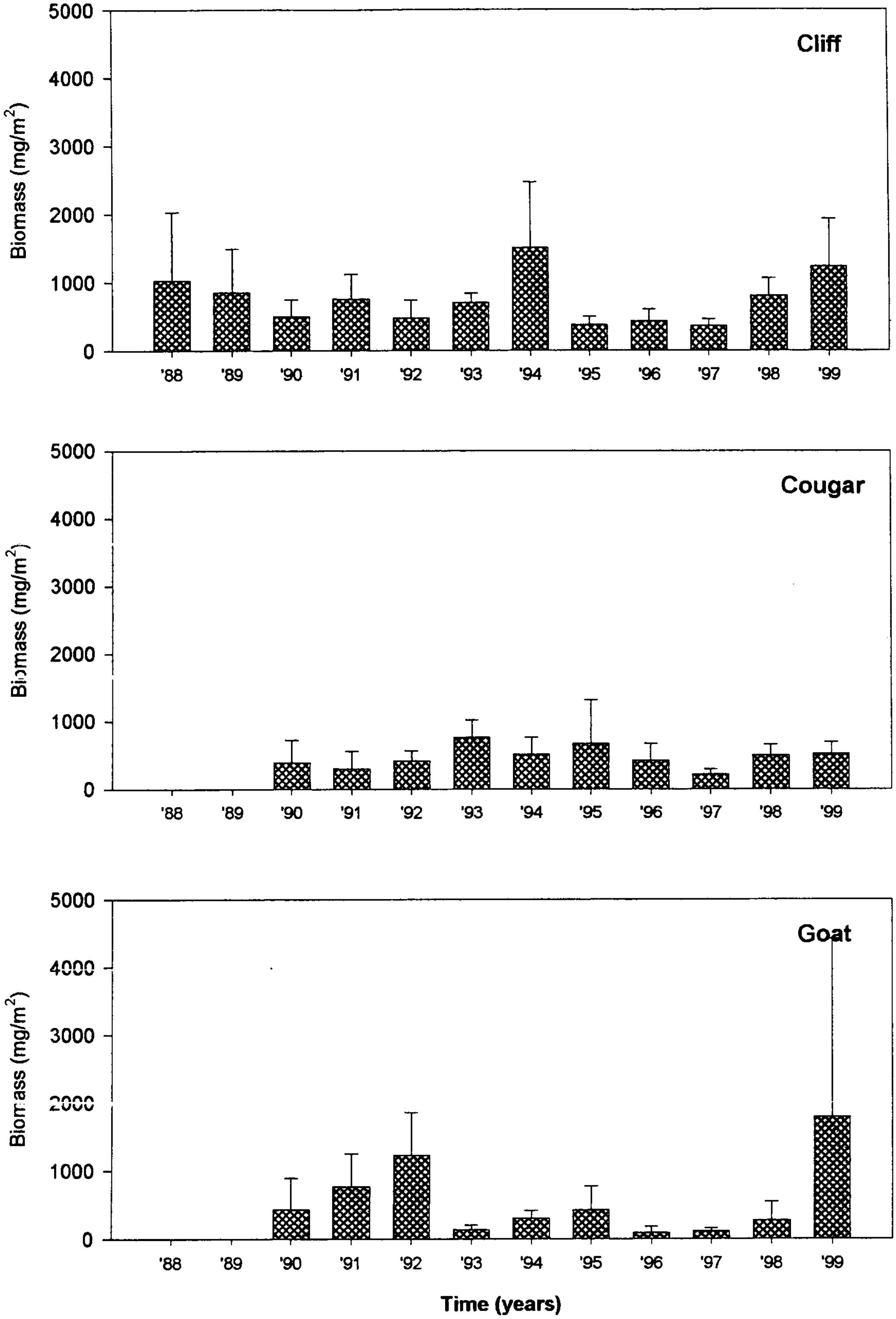

Figure 5 continued.

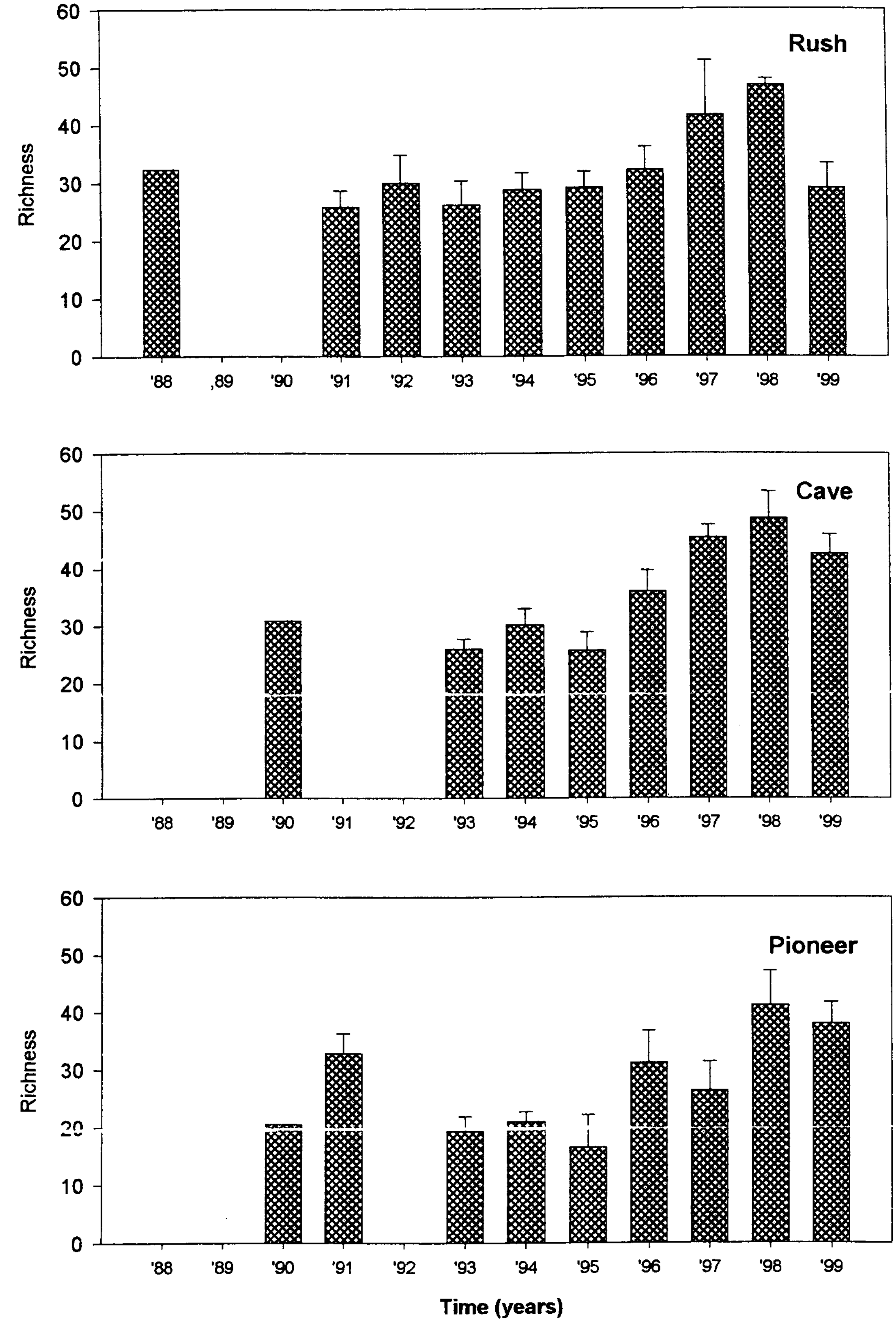

Figure 6. Mean macroinvertebrate richness for each stream. Error bars equal +1SD from the mean, n=5.

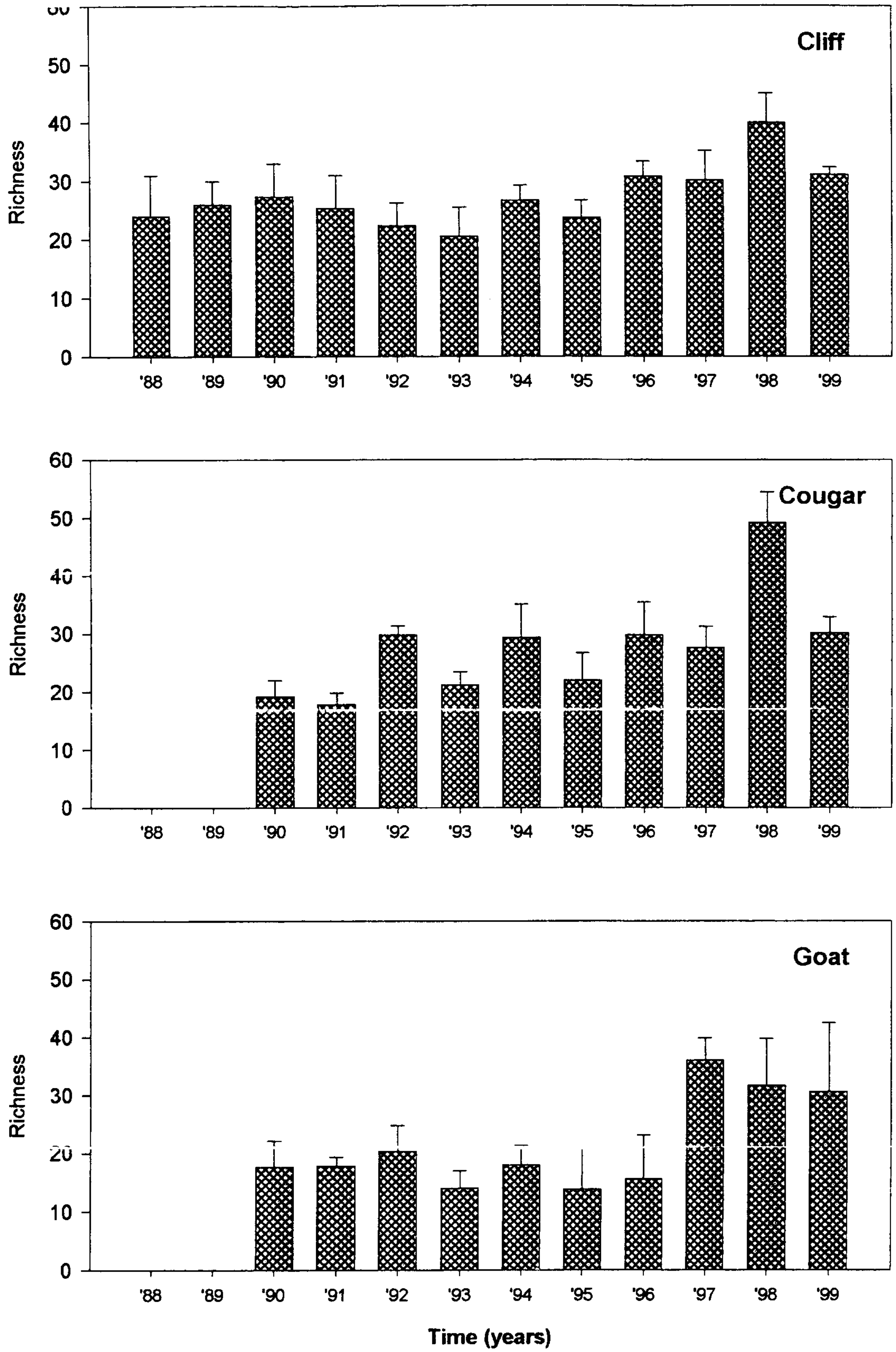

Figure 6 continued.

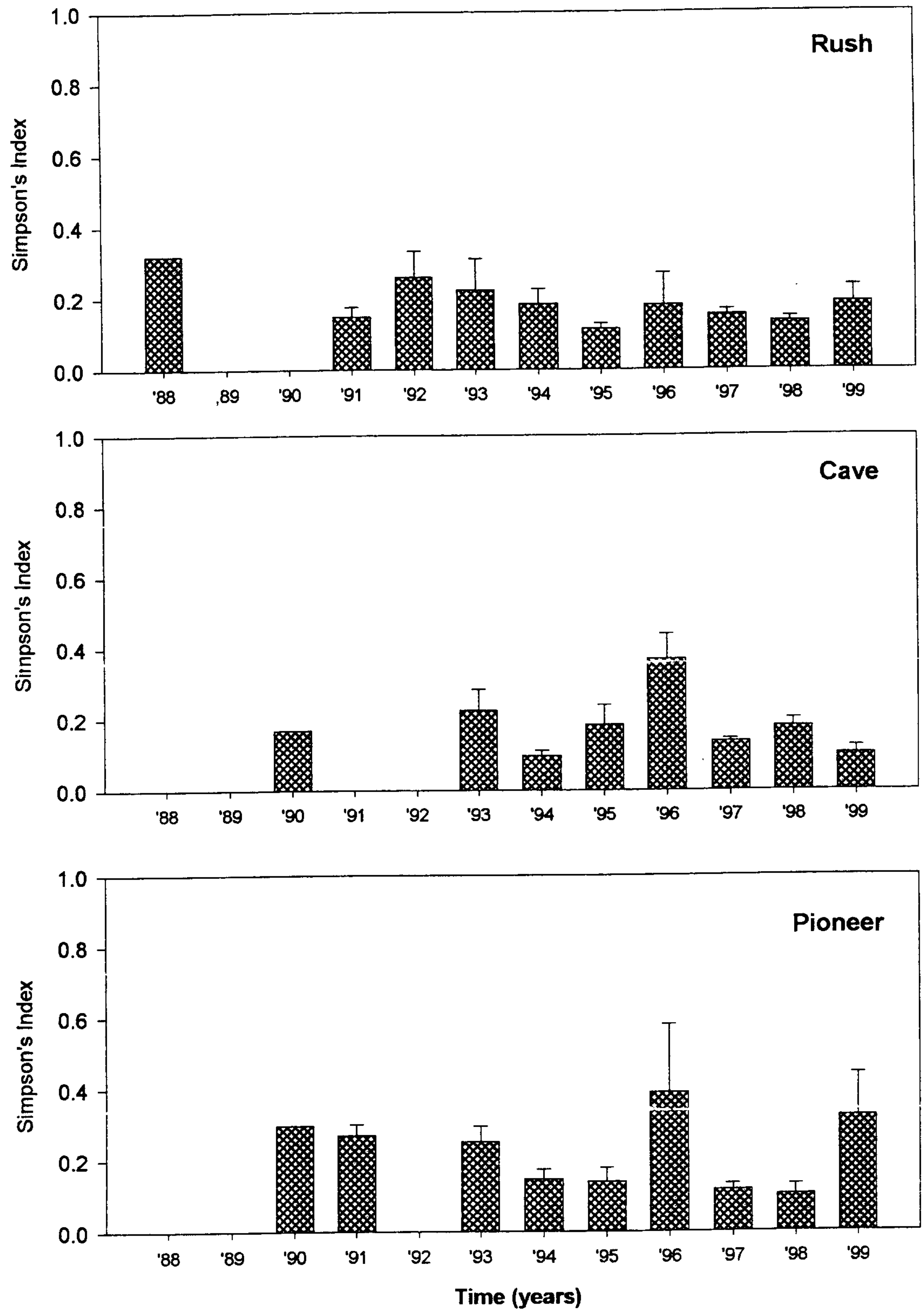

Figure 7. Mean macroinvertebrate Simpson's Index for each stream. Error bars equal +1SD from the mean, n=5.

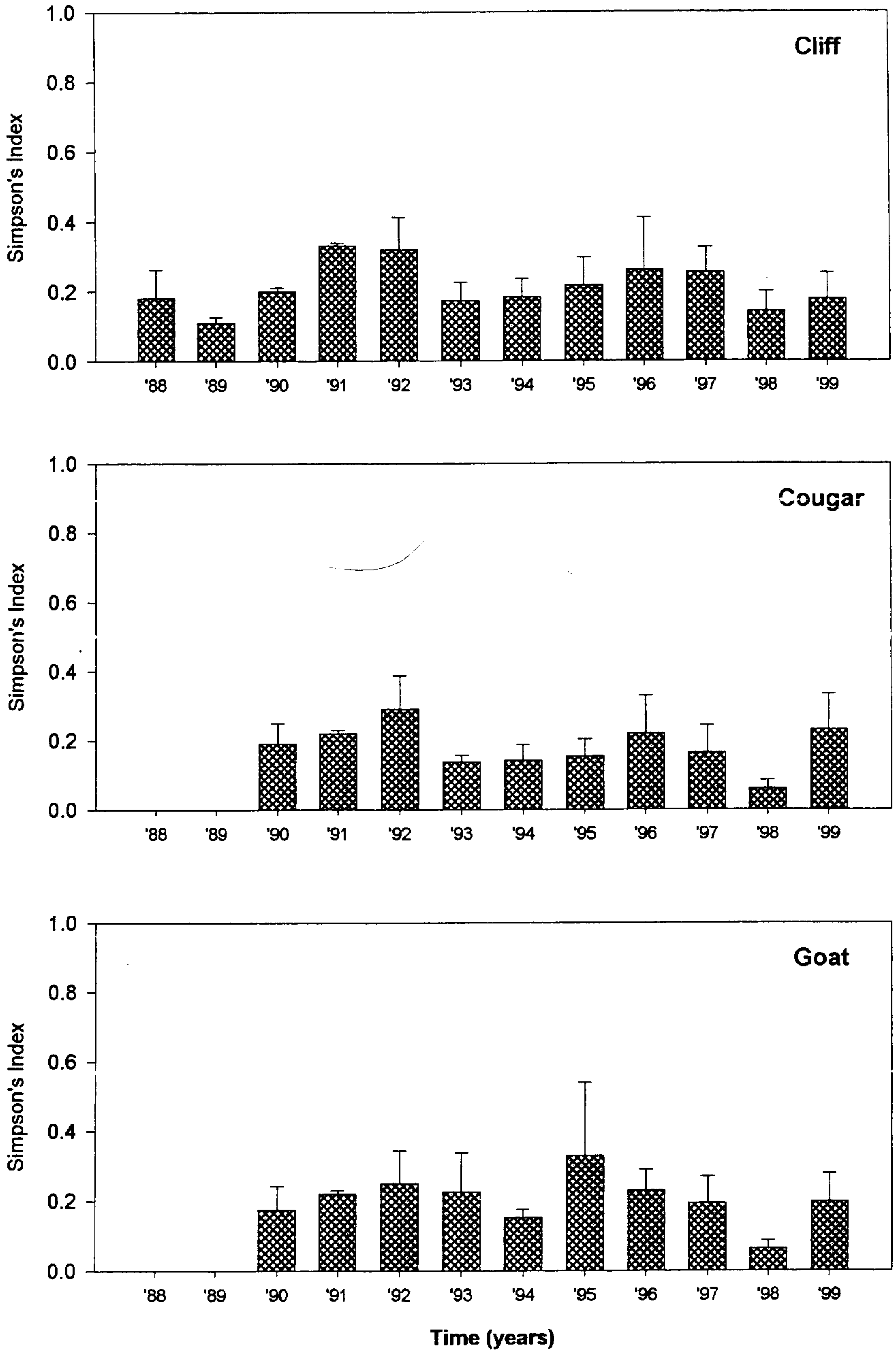

Figure 7 continued.

0.32 (Figure 7). Values increased at all sites between 1998 and 1999, except for Cave Creek in which it decreased. Values for all sites fell within the long-term range. Simpson's Index has been the most variable community metric over the 11-year period, but has remained fairly low indicating high diversity. In previous years, Goat Creek has typically displayed the lowest invertebrate density, biomass, and diversity of any of the streams sampled. This year that was not the case, but likely is due to the large standard deviation. The standard deviation for taxa richness in Goat Creek was 12 taxa while the variance of the other streams was less than 4 taxa.

South Fork of the Salmon River Tributaries

Only minor changes have been observed in the measured water chemistry variables in Circle End, Tailholt, and Big Flat Creeks (Table 6). In 1999, all streams increased in alkalinity. Circle End increased in hardness while the other streams remained the same or decreased. Circle End and Tailholt Creeks contain considerably more dissolved solids than does Fritser. Also, specific conductance is 5-6 fold greater and alkalinity 3-4 fold greater in Circle End and Tailholt than in Fritser (Table 6). In addition, while Fritser and Smith are similar in discharge (0.37 and 0.42 m^3/s), Smith contains more dissolved solids. Among the sites in the salvage logging area, conductance and alkalinity varied considerably between Smith Creek and Big Flat Creek (Table 6). Big Flat was most similar to Tailholt in water chemistry measures although they were located in separate watersheds, the middle vs. lower South Fork Salmon River watersheds.

Discharge values were similar to those of previous years except for Circle End and Smith Creek, which increased from 0.01 to 0.13 and 0.12 to 0.42 m^3/s, respectively (Table 6). All of the streams sampled in previous years remained fairly consistent in substrate size between 1998 and 1999 (Table 7). Mean substrate size is similar between Tailholt and Circle End (reference streams), 14 and 11 cm respectively and mean substrate size increased slightly (by approximately 4 cm in each stream) between 1998 and 1999. However, substrate size in Circle End was based on fewer measurements due to the high amount of bedrock recorded as habitat (52% of the measurements). Fritser Creek (burned) mean substrate size in 1999 was not substantially different from 1998 (19 and 22 cm) but has steadily declined in size since 1995 (Table 7). Substrate size in (burned and logged) Big Flat Creek was the largest of all the study sites examined due to the

Table 6. Discharge and chemical measures for the study streams in the S. Fork Salmon catchment. NS = no sample, NA = not available

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)
Circle End	1994	0.01	NS	NS	186
	1995	0.01	52	68	149
	1996	0.01	40	65	129
	1998	0.01	58	69	NS
	1999	0.13	84	85	112
Tailholt	1994	0.02	NS	NS	143
	1995	0.06	30	56	108
	1996	0.07	28	53	76
	1998	0.05	39	48	NS
	1999	0.09	67	49	85
Fritser	1995	0.27	10	28	27
	1996	0.42	10	20	NA
	1998	0.14	21	28	NS
	1999	0.37	24	21	23
Smith	1996	0.12	16	44	54
	1998	0.12	25	40	NS
	1999	0.79	38	23	40
Big Flat	1996	NS	24	57	102
	1998	0.05	41	59	NS
	1999	0.42	60	39	90

Table 7. Substrate particle size and channel morphology measures for study streams in the South Fork Salmon catchment. SD = standard deviation, CV = coefficient of variation. R=reference, B=burned in 1994, S=logged in 1996. NS = no sample.

		Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Circle End (R)	1994	14.0	39.0	2.89	38.0	45.0	1.16	0.7	0.2	4.0	3.0
	1995	30.0	27.0	0.89	64.0	29.0	0.46	1.2	0.4	5.0	5.0
	1996	19.0	44.0	2.32	58.0	42.0	0.72	1.3	0.5	7.0	6.0
	1998	7.6	13.0	1.71	39.5	41.7	1.06	3.8	1.6	5.4	5.1
	1999	11.0	9.7	0.88	8.5	22.1	2.60	3.5	0.7	5.4	4.3
Tailholt (R)	1994	13.0	30.0	2.35	23.0	33.0	1.46	1.2	0.2	10.0	5.0
	1995	20.0	30.0	1.47	76.0	30.0	0.39	1.7	0.2	19.0	11.0
	1996	13.0	30.0	2.31	72.0	37.0	0.51	1.7	0.6	15.0	9.0
	1998	8.9	14.1	1.59	64.3	41.6	0.65	3.3	0.6	14.5	9.1
	1999	13.6	19.4	1.42	14.3	25.8	1.81	2.1	0.6	16.7	13.1
Fritser (B)	1995	42.0	36.0	0.84	55.0	33.0	0.60	2.8	0.4	26.0	19.0
	1996	23.0	38.0	1.65	58.0	39.0	0.67	2.4	0.9	18.0	12.0
	1998	21.5	29.6	1.38	55.5	36.2	0.65	5.6	2.0	17.9	13.4
	1999	19.1	30.1	1.58	18.8	21.0	1.12	5.2	0.8	28.5	16.8
Smith (R)	1996	13.0	11.0	0.85	51.0	39.0	0.76	3.2	0.3	17.0	9.0
	1998	19.3	26.4	1.37	45.1	28.2	0.63	5.4	2.2	15.2	11.5
	1999	18.7	20.2	1.08	17.0	26.0	1.52	5.2	0.8	24.3	13.8
Big Flat (S)	1996	NS			NS			NS		NS	
	1998	23.9	36.2	1.52	37.5	36.7	0.98	3.9	1.8	7.5	7.4
	1999	27.7	36.5	1.32	5.8	13.6	2.37	3.1	0.4	8.6	8.2

presence of large boulders (defined as >256 mm) in the streambed. Mean substrate size remained fairly similar between 1998 and 1999 (24 and 28 cm). Smith Creek mean substrate size also remained consistent between 1998 and 1999 (~ 19 cm) but has increased from 13 cm since 1996.

Mean substrate embeddedness decreased substantially at all sites between 1998 and 1999. Embeddedness decreased from 40 to 9% in Circle End and from 64 to 14% in Tailholt Creek (Table 7). Fritser Creek substrate embeddedness decreased from a 1995-1998 average of 56% to 19% in 1999 (Table 7). Big Flat Creek embeddedness decreased from 38% to 6% between 1998 and 1999 (Table 7). In Smith Creek, substrate embeddedness decreased considerably from a 1996-98 average of 48% to 17% in 1999 (Table 7).

All streams were slightly narrower and deeper in 1999 than in 1998 (Table 7). Tailholt Creek width decreased from 3.3 to 2.1 m and depth increased from 15 to 17 cm. Circle End, more confined in its valley, changed only slightly between 1998 and 1999 decreasing in mean width from 3.8 to 3.5 m while the baseflow depth remained near 5 cm. While Fritser Creek bankfull width in 1999 was similar to widths measured in 1996 and 1998, baseflow depth increased from 18 to 29 cm between 1998 and 1999 (Table 7). Big Flat Creek decreased in bankfull width, from 4 to 3 m, between 1998 and 1999 and mean baseflow depth increased by 1 cm. Smith Creek bankfull width was similar to 1998, 5 m, while baseflow depth increased from 15 cm to 24 cm in 1999 (Table 7).

Periphyton chlorophyll *a* in the South Fork Salmon sites ranged from 1.7 mg/m^2 and Fritser to 16.0 mg/m^2 at Smith Creek (Figure 8). Mean chlorophyll a in Big Flat Creek was approximately 5 mg/m^2, this was not substantially different from Smith Creek due to the large variance at Smith Creek. Periphyton chlorophyll *a* in Fritser Creek in 1999 was lower than previous years, but was not different from Tailholt (1.9 mg/m^2), one of its reference streams (Figure 8). Circle End Creek chlorophyll *a* values, 11±13 mg/m^2, may have been skewed by the attempt to find substrate large enough to sample periphyton. In our 100 habitat heterogeneity substrate size measurements, habitat was recorded as bedrock at 52 locations. Due to technician error, periphyton chlorophyll *a* data was lost in 1998 therefore a comparison could not be made. Periphyton AFDM was highest in Circle End (11 g/m^2) and lowest in Big Flat Creek (3 g/m^2) (Figure 8). The high value at Circle End Creek was likely due to the large amount of *Nostoc* and enmeshed organic matter on the substrate. Similar to chlorophyll, periphyton biomasses in Big

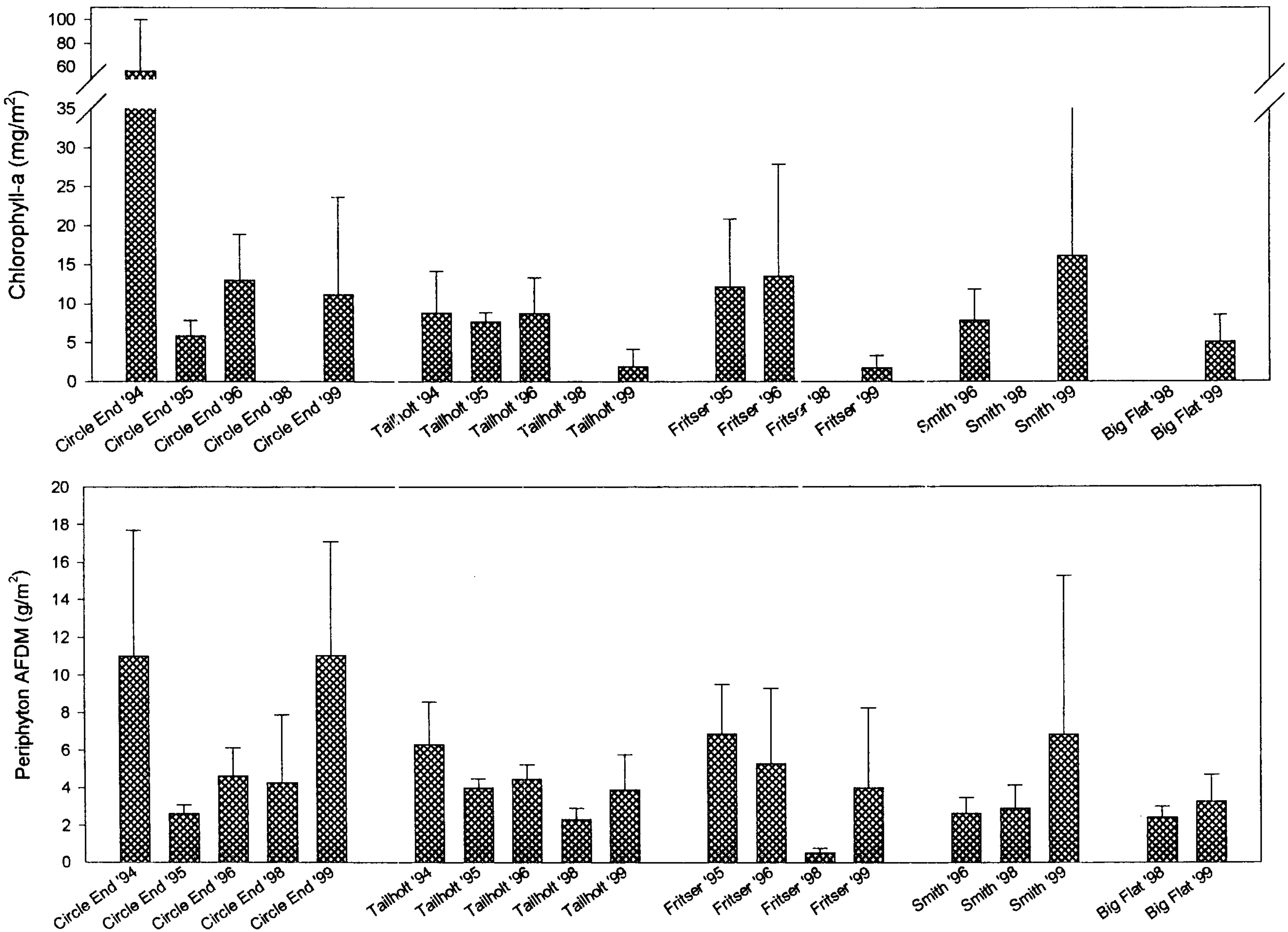

Figure 8. Mean periphyton chlorophyll *a* and ash-free dry mass (AFDM) in each stream, 1994-1999. Error bars equal +1SD, n=5. Big Flat Creek data was not collected in 1996 and lost due to technician error in 1998.

Flat and Smith Creeks were not substantially different from one another. Fritser and Tailholt Creeks AFDM also were not substantially different (Figure 8). Benthic organic matter (BOM) decreased in both Smith and Big Flat Creeks between 1998 and 1999 and the stream values were not notably different from each other, 12 and 13 g/m^2, respectively (Figure 9). Mean BOM increased in Circle End and Fritser Creeks between 1998 and 1999 but remained fairly stable in Tailholt Creek (Figure 9). The highest BOM value in 1999 was 44 g/m^2, recorded at Fritser Creek but the standard deviation was equal to the mean. Transect 1 at Fritser Creek had 5x the BOM that any of the other transects had; without it the mean BOM at Fritser Creek falls between the values recorded for Tailholt and Circle End Creeks. Mean BOM values were higher in the Middle South Fork Salmon River Watershed (Tailholt, Circle End, and Fritser Creeks) than in the Lower Watershed (Big Flat and Smith Creek) sites (Figure 9).

Benthic macroinvertebrate mean density for all streams ranged from 1761 in Big Flat Creek to 10,040 individuals/m^2 in Circle End Creek (Figure 10). Fritser Creek mean density was similar to that of Tailholt Creek, approximately 2500 individuals/m^2, but both streams were low compared to Circle End Creek. Big Flat Creek was low compared to its reference stream, Smith Creek, which had 9157 individuals/m^2. Densities in 1999 were lower than in 1998 for all streams except for Smith Creek(Figure 10). Fritser, Tailholt, and Big Flat Creeks had the lowest densities recorded in any of the various numbers of years that they have been sampled. Smith Creek mean density was the highest density recorded in that stream in the three years that it has been sampled, but also had a high standard deviation (6845 individuals/m^2).

Macroinvertebrate mean biomass (mg/m^2) was lowest in Big Flat Creek, 447 mg/m^2 and highest in Circle End Creek, 1126 mg/m^2 (Figure 10). Due to technician error, a portion (Ephemeroptera and Plecoptera orders) of the Tailholt Creek biomass was lost for 1999 and was estimated by calculating an average weight for each lost species from the previous four years of data in that stream. Biomass trends did not follow density trends in all streams. While density decreased in Circle End Creek between 1998 and 1999, biomass increased. More than 40% of the 1999 biomass in the stream is due to *Baetis* (22%) and Chironomidae (20%). In 1998, 34% of the biomass was due to Chironomidae, and 31% to *Baetis*. Mean macroinvertebrate biomass, remained within the 4-5 year range sampled in the streams in the Upper South Fork Salmon Watershed, while streams in the lower portion of the watershed have remained fairly constant

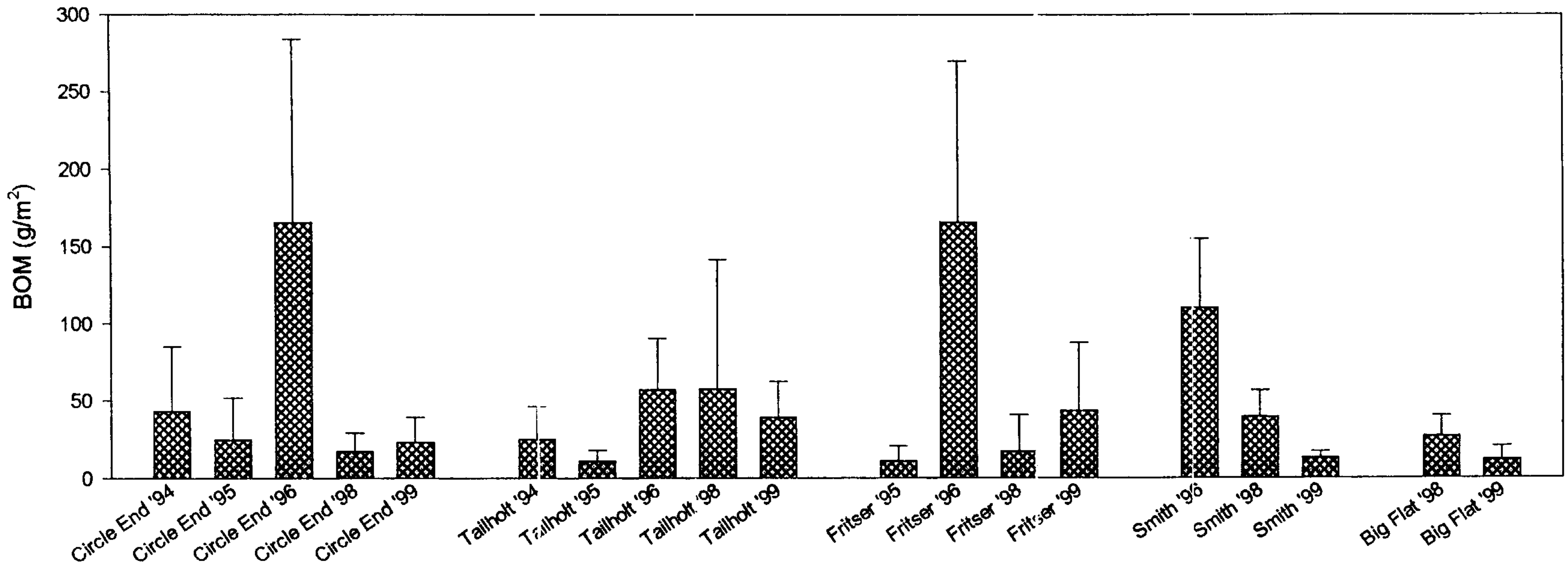

Figure 9. Mean benthic organic matter (BOM) dry mass in each stream, 1994-1999. Error bars equal +1SD from the mean, n=5. Big Flat Creek data was not collected in 1996.

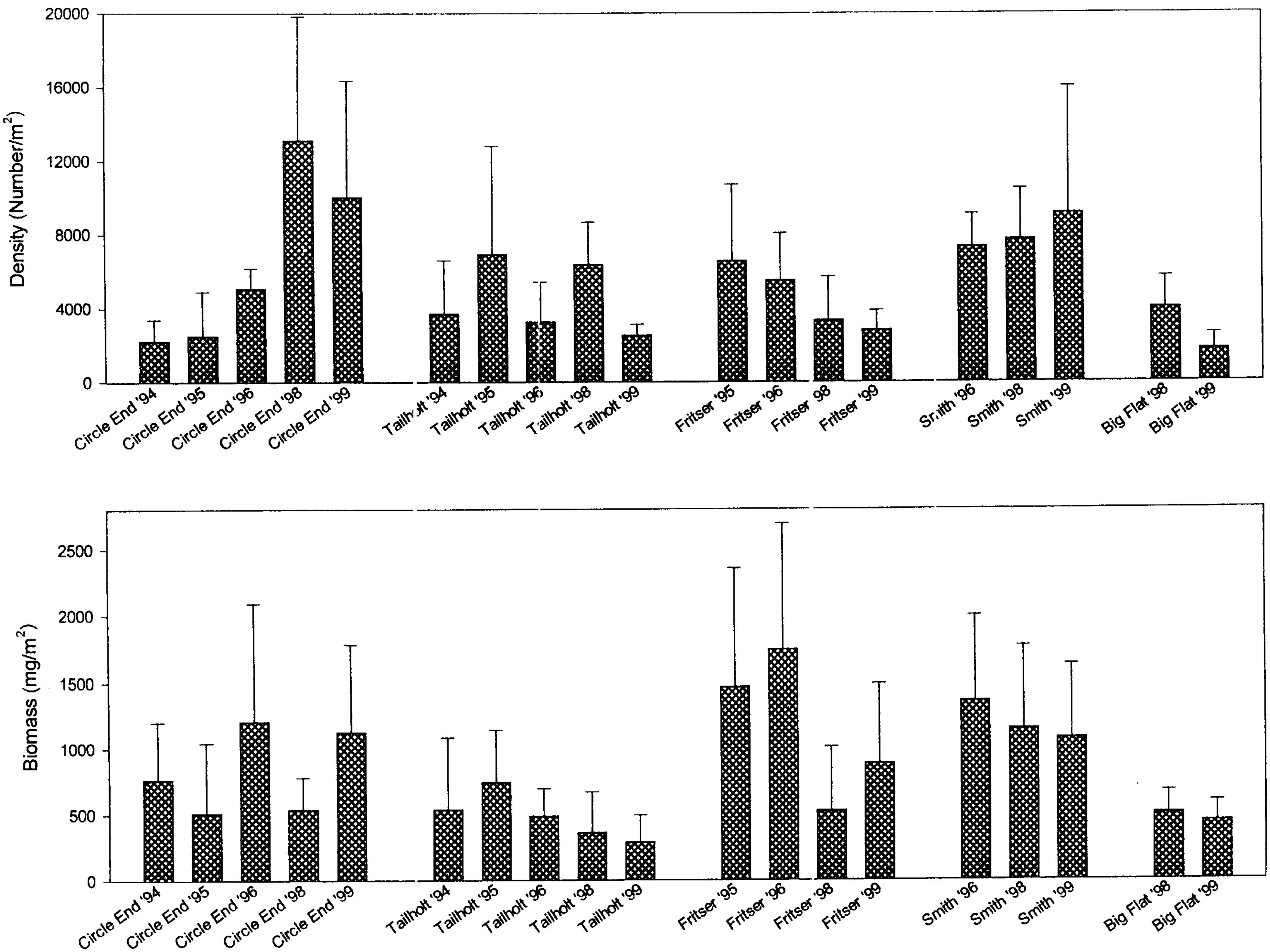

Figure 10. Mean macroinvertebrate density and biomass for each stream, 1994-1999. Error bars equal +1SD from the mean, n=5.

over the three years sampled (Figure 10).

Taxa richness ranged from 23 to 31 taxa at Tailholt and Circle End/Smith Creeks (both had 31 taxa), respectively (Figure 11). Between 1998 and 1999, mean taxa richness remained consistent in Circle End and Fritser Creeks and decreased in the remaining streams. Richness decreased substantially at Tailholt and Smith Creeks, by approximately 13 taxa. Simpson's Index was lowest at Fritser Creek, 0.15, and highest at Tailholt, 0.34 (Figure 11). Values remained the same or increased at all sites between 1998 and 1999, except for Circle End Creek in which it decreased. Values for Smith and Tailholt were high compared to previous years, but had high variances as well.

In all streams Baetidae, Chironomidae, and Oligochaeta ranked in the top four of the most abundant macroinvertebrates present. In Fritser Creek, *Baetis* was the most common taxon and comprised 25% of the community (Table 8). Chironomidae was similar in relative abundance, 24%. Tailholt and Smith were dominated by Oligochaeta, 50% and 26% with *Baetis* in second at 12% and 22%. Circle End and Big Flat Creek were dominated by Chironomidae, 47%, and 29%, respectively, and *Baetis* made up 17% and 20% of the community. Other commonly occurring species included *Ampumixis* (an Elmidae genus), *Epeorus,* Hydracarina, Nematoda, *Cinygmula,* and several species of *Rhyacophila* (Table 8).

DISCUSSION

Wildfire is a major large scale disturbance that affects stream ecosystems over broad spatial and temporal scales. The present study took advantage of the unique opportunity to examine the short-term (first 5 years) and midterm (next 6 years) recovery pattern in a set of streams affected by wildfire. Annual data collected on these streams, collected with the same methods, enhances the study for addressing hypotheses regarding temporal recovery patterns among streams. The severity of a disturbance has on the ecological conditions of a stream ecosystem can be gaged by determining if the event resulted in conditions outside the normally observed range of variability. These data also provide ranges for the natural range of variability that occurs in wilderness streams.

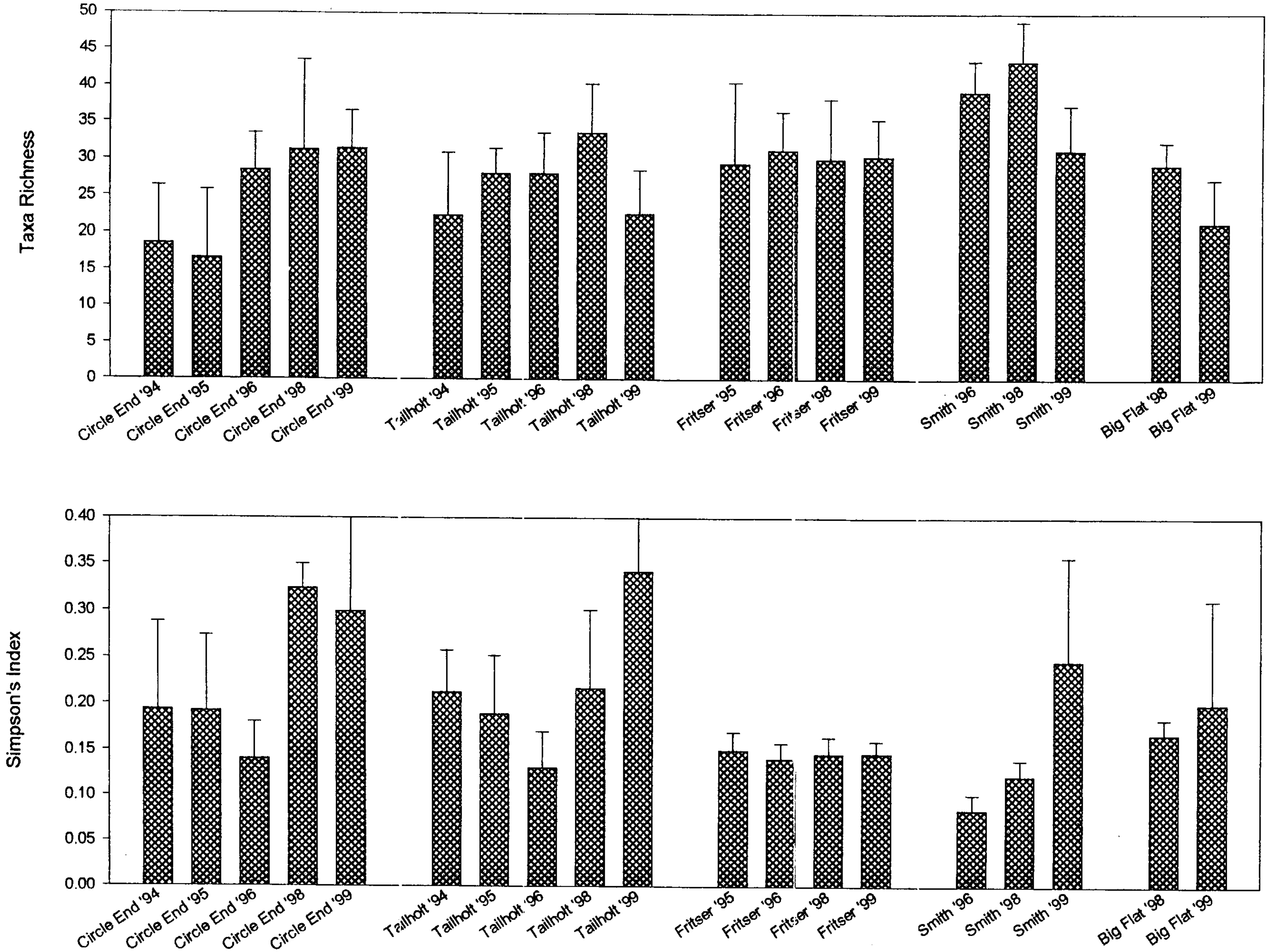

Figure 11. Mean macroinvertebrate taxa richness and Simpson's Index for each stream, 1994-1999. Error bars equal +1SD from the mean, n=5.

Table 8. Relative abundances of the 15 most common macroinvertebrate taxa from each stream, 1999. SD = one standard deviation from the mean, n=5.

Fritser

	Mean	SD
Baetis	0.247	0.043
Chironomidae	0.242	0.016
Oligochaeta	0.063	0.044
Ampumixis	0.056	0.029
Nematoda	0.050	0.031
Epeorus longimanus	0.048	0.026
Ostracoda	0.047	0.023
Hydracarina	0.039	0.011
Drunella coloradensis	0.032	0.007
Clinocera	0.020	0.016
Dolophilodes	0.012	0.016
Lara	0.011	0.009
Yoraperla brevis	0.011	0.007
Cinygmula	0.008	0.007
Rhyacophila	0.007	0.009

Tailholt

	Mean	SD
Oligochaeta	0.503	0.225
Baetis	0.119	0.064
Ampumixis	0.071	0.058
Chironomidae	0.063	0.048
Epeorus longimanus	0.026	0.015
Sweltsa	0.025	0.004
Hydracarina	0.025	0.018
Rhyacophila sibirica	0.021	0.013
Nematoda	0.020	0.014
Leuctridae	0.019	0.006
Cinygmula	0.015	0.017
Drunella coloradensis	0.013	0.009
Epeorus grandis	0.009	0.006
Collembola	0.008	0.006
Megarcys	0.007	0.007

Big Flat

	Mean	SD
Chironomidae	0.291	0.168
Baetis	0.200	0.060
Oligochaeta	0.099	0.114
Ampumixis	0.066	0.032
Yoraperla brevis	0.052	0.038
Zapada	0.044	0.031
Nematoda	0.024	0.013
Drunella coloradensis	0.023	0.021
Serratella tibialis	0.022	0.028
Elmidae	0.018	0.022
Neophylax	0.017	0.012
Epeorus longimanus	0.016	0.020
Hydracarina	0.015	0.009
Lara	0.012	0.016
Megarcys	0.011	0.013

Circle End

	Mean	SD
Chironomidae	0.466	0.182
Baetis	0.169	0.051
Oligochaeta	0.062	0.047
Zapada	0.056	0.017
Serratella tibialis	0.046	0.011
Ostracoda	0.032	0.034
Simulium	0.026	0.020
Nematoda	0.018	0.019
Epeorus longimanus	0.016	0.006
Rhyacophila	0.012	0.007
Tricladida	0.011	0.014
Paraleptophlebia memorialis	0.009	0.012
Hydracarina	0.008	0.005
Ampumixis	0.007	0.004
Cinygmula	0.006	0.005

Smith

	Mean	SD
Oligochaeta	0.261	0.222
Baetis	0.222	0.113
Drunella doddsi	0.198	0.096
Chironomidae	0.085	0.074
Epeorus grandis	0.029	0.023
Nematoda	0.022	0.016
Elmidae	0.020	0.015
Cinygmula	0.013	0.008
Ampumixis	0.012	0.013
Drunella coloradensis	0.011	0.008
Ostracoda	0.011	0.006
Ephemerellidae	0.011	0.022
Hydracarina	0.011	0.003
Heterlimnius	0.010	0.006
Megarcys	0.009	0.005

Big Creek Tributaries

In the Big Creek catchment, the range of stream sizes (2^{nd} to 5^{th} order) selected allowed for the examination of spatial aspects in addition to the long-term temporal effects of wildfire. Our research during the summer of 1999 showed no evidence of changes in water chemistry between 1998 and 1999. This was as expected because this is the eleventh year of the study and it has been demonstrated that chemical changes occur immediately following a fire but dissipate in less than three years as the riparian vegetation recovers (Minshall et al. 1989, Robinson and Minshall 1996). The riparian area in our immediate study locations was not severely impacted by fire and has since stabilized. Discharge was consistent between years. Essentially no temporal change was observed between years in physical habitat as well. The mean bankfull width and baseflow depths fall within the long-term means. The burned streams were not scoured to a greater extent than were the unburned streams between 1998 and 1999. It appears that the Golden and Rush Point fires have not been a major influence on the year-to-year change in the physical and chemical habitat of Cliff, Cougar, Goat, Pioneer, or Rush Creeks.

Periphyton chlorophyll *a* was lower in most and ash-free dry mass (AFDM) was lower in all streams in 1999 than in 1998. Mean benthic organic matter values also remained fairly consistent between years in all streams. The means of all of these variables also fell within the long-term means.

Benthic macroinvertebrate densities were lower in 1999 than in 1998 for all streams except for Goat Creek. With the exception of Goat Creek, macroinvertebrate densities were consistent with the long-term means. Macroinvertebrate biomass was more stable over time in all streams compared to density. Taxa richness and Simpson's Index also remained consistent with the long-term trends observed in all streams.

It appears that the Golden Fire and Rush Point Fires have not been major influences on the abiotic and biotic structure of the Big Creek tributaries.

South Fork Salmon River Tributaries

Discharge in the South Fork Salmon sites was higher in 1999 than in 1998 and alkalinity increased. These streams were sampled earlier in the year than usual (early vs. late July) due to time constraints and were still experiencing spring runoff. Although substrate size remained fairly consistent between years, mean embeddedness decreased substantially and the streams tended to be narrower and deeper than in 1998. However, they are not narrower than the long term mean and are likely showing recovery from the severe (100 year flood) 1997 disturbance event. This is true for both the unburned (Tailholt and Circle End) and moderately burned streams (Fritser Creek). Fritser likely did not show as much disturbance to the 1997 event as predicted based on its burned condition due to the large amount of bedrock in its streambed. Big Flat Creek, burnt and then salvage logged, followed the same trend in bankfull width and depth as the other burned streams. Its reference stream, Smith Creek, only slightly decreased in width and significantly increased in depth; discharge increased from 0.12 to 0.42 m^3/s.

Periphyton chlorophyll *a* data was lost in 1998 due to technician error so between year comparisons cannot be made. In streams where the standard deviation was low, periphyton chlorophyll *a* mean was low for the five-year average. In other streams, with high standard deviations, values were within the five-year range. BOM decreased between 1998 and 1999 in both Smith and Big Flat Creeks (Lower SFSR Watershed sites) and increased in the rest of the streams (Middle SFSR Watershed sites).

Fritser Creek has consistently decreased in macroinvertebrate density from 1995 to 1999 (6,500 to 2,850 individuals/m^2). While biomass has been variable, taxa richness and Simpson's Index have remained remarkably consistent. Overall, Fritser was not notably different from its reference streams. Although Circle End had 5x the density of Fritser Creek, the biomasses were fairly similar between streams. Taxa richness in Fritser Creek was equal to or higher than both of the reference streams and Simpson's Index was lower, again indicating no substantial sign of disturbance from the 1994 Chicken Fire between these sets of streams.

Big Flat Creek had substantially fewer individuals/m^2 and less biomass (mg/m^2) than did its reference stream, Smith Creek. Taxa richness was lower in Big Flat than in Smith Creek, especially on a year-to-year comparison. Simpson's Index has previously been lower in Smith Creek than in Big Flat Creek, but was higher in 1999. Seventy percent of the 1999 Smith Creek community can be attributed to three taxa, Oligochaeta, *Baetis*, and *Drunella doddsi*. While there is some difference in the size of these streams that may be minimally be influencing the comparison, it is more likely due to the effects of the Chicken fire and subsequent salvage logging on account of changes in habitat. Big Flat, although sampled qualitatively in 1996, had approximately 41 taxa and shows an appreciable loss of taxa between pre- and post-logging events.

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